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Tuan Q. Phan *Editors*

# Information Systems Research in Vietnam, Volume 2

## A Shared Vision and New Frontiers

Springer

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# Introduction to Information Systems Research in Vietnam: Current Progress and New Frontiers


**Duy Dang-Pham, Ai-Phuong Hoang, Hoanh-Su Le, Tuan Q. Phan, and Nguyen Hoang Thuan**

**Abstract** The current chapter introduces the book Information Systems research in Vietnam (Volume 2), which seeks to address research opportunities in the Vietnamese environment. It introduces nine selected chapters of the book that cover diverse information systems research topics, including digital advertisements, e-commerce and brand addiction behaviours, artificial intelligence (AI) applications in the aviation industry and solar energy construction, online education effectiveness, information security awareness, potential market for elderly people, and sustainable digital transformation. The chapter further outlines the significance of sustainability in the process of digitization and argues that future IS research may aid in achieving sustainability objectives. Through the assistance of the Vietnam Chapter of the Association for Information Systems (VAIS), this book invites international scholars to conduct collaborative IS research in Vietnam.

**Keywords** Information systems · Information systems research · Vietnam

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## 1 Introduction

The rapid development of Information Systems (IS) and inevitable surge of new digital technologies have led to an important topic of interest, among scholars and practitioners in Vietnam. IS research in Vietnam is making a great progress with diverse and emerging research topic across various fields like artificial intelligence (AI), learning analytics, and collective intelligence [14]. IS has been at the forefront of the recovery in Vietnamese businesses and society post Covid-19. Its applications leave a footprint on various fields like generative AI, online learning, electronic commerce (e-commerce), deep learning and digital transformation. Building upon the successful foundation established in the book Information Systems research in Vietnam (Volume 1) that sets the background for the shared accountability of IS knowledge in Vietnam [14], this second edition continues to highlight the current frontiers of IS research and practices in Vietnam.

This book aims to address the challenges and seize the opportunities of IS in Vietnamese context, particularly focusing on the impact of emerging IS trends and the Vietnam's unique context. It further aims to provide readers an overview in the Vietnam's IS sector with access to practical IS applications. The book also illustrates how IS research drives digital innovation and emerging technologies to design and support individuals and organizations. By comparing the context of IS applications between Vietnam and other countries, this book will not only assist the Vietnamese IS academics, but also international scholars who are interested in engaging with Vietnamese context.

In this book, we put emphasis on the development of innovative IS artifacts. This book will delve deeper into various emerging IS case studies and applications as well as studies on future IS direction. In particular, the book chapters address the current topic in IS field, including digital advertisements, e-commerce and brand addiction behaviors, AI applications in the aviation industry, AI application for fault detection in solar energy construction, online education effectiveness, information security awareness, potential market for elderly people, and sustainable digital transformation.

By compiling a series of research, case studies, and applications in IS that tackle the challenges and capitalize on the opportunities unique to Vietnam, this book aspires to create a Vietnamese-oriented body of research on IS that can meet the needs of scholars and practitioners to make a positive impact on Vietnam. We hope to provide a valuable point of reference for the IS field in Vietnam and align with the shared vision of the community. The findings from chapters in this book will be instrumental in informing and guiding future strategies and actions, inspiriting both scholars and researchers to effectively navigate the dynamic landscape of IS in Vietnam.

## 2 IS Research in Vietnam

IS research investigates the use of information technology (IT) in a socio-technical system, involving both individuals, organizations, and IT artifacts. As such, the IS discipline is diverse and dynamic by nature. The first volume of this book has provided a comprehensive overview of IS-related phenomena in Vietnam [14]. We highlighted the usage, application, and expansion of IS to create values in different industries in Vietnam and its vital role in dealing with the COVID-19 pandemic. Drawing on a wide collection of individual-level and organizational-level theories, we explored IS themes ranging from enterprise system, enterprise architectures, supply chain management and outsourcing to information security, and more. Currently, Vietnam has recovered from the pandemic with a fast post-COVID-19 economic recovery, demonstrating its resilience and adaptability in the face of unprecedented challenges. It is, therefore, important to re-examine the advancements of the IS domain along the way. In light of this context, the fields that draw significant attention of the IS practitioners and scholars in Vietnam are the digital transformation process, human-centric AI, deep learning, e-commerce, and online education.

Recently, the topic of digital transformation, AI, and online learning emerge as an important phenomenon across business and management discipline. Regarding the former, Theiri and Alareeni [17] examines the impact of digital transformation on the pandemic within Tunisian banking industry by identifying how digitalization can be leveraged to seize opportunities and develop innovative strategies. Bai et al. [4] attempt to explore the impact of digital transformation on the sustainable development of micro-and small-enterprises amid COVID-19 pandemic. Others touch on how digital transformation further enhances organizational resilience and agility [2]. Enterprises have embarked on digital transformations and initiatives to meet the emergent needs in the post-pandemic era [11].

In same vein, AI disrupts the current state of IS with its potentiality to replace humans, transform conventional way of performing any tasks and augment organizational growth. Research on AI is diverse with its application demonstrated across various fields like business management [7], sustainable entrepreneurship [9]; COVID-19 containment [10], higher education institutions [6], cyberspace and cybersecurity [20], wearable devices [12], geotechnical engineering [3], and many others. With deep learning method, a subfield of AI-based approaches, have been emergently employed in enterprise area like business analytics and business process prediction [13, 16]; healthcare [1]; or supply chain risks [5]. Finally, it is worthwhile to mention the rise of online learning [15], that has become the prevalent study mode. With these recent developments, we expect that IS research in Vietnam can further progress on digital transformation, AI, and online learning.

## 3 Introducing the Book Chapters

The research interests among IS practitioners and scholars in Vietnam are aligned well with the current body of IS knowledge. Given this diverse array of studies and perspectives, we explore the IS literatures in Vietnam, encompassing emerging topics such as digital transformation, AI, online learning, and e-commerce to understand the problems and seize the opportunities. This book sets out to explore the current state of the IS research fields in Vietnam. In line with this objective, we issued a call for IS research contributions in Vietnam, which resulted in 18 manuscript submissions. Following two rounds of blinded peer-review and revisions, we selected a total of nine chapters for this second volume.

After this introduction chapter, in chapter "Digital Transformation and Gender Representation: A Study of Service Advertisements in Vietnam", Nguyen et al. performed a content analysis of 300 digital service commercials to analyze gender representation in service advertisements in Vietnam. Their results highlighted a shift in gender representation through the two periods (2012–2017 and 2018–2022), in which recent advertisements portrayed more collaboration between female and male representatives, as well as more femvertising messages. Their research shed light on the current situation concerning gender roles and stereotypes in digital advertisements in Vietnam, and provided recommendations for policymakers and advertising professionals to create more balanced and non-stereotypical gender representations in the future.

Next, Le and Tran investigated Vietnamese consumer behaviors with regard to e-commerce and digital financial services during and beyond the pandemic time in chapter "E-Commerce and Digital Financial Services During COVID-19 and Potential for Expansion in Post-Pandemic: Insights from Vietnamese Consumer Behaviors". They collected survey data from five major cities in Vietnam and performed content analysis to explore various consumers' behaviors of online shopping, particularly their health and safety concerns, reasons for online shopping, technology readiness, and their plan to continue using e-commerce services after the pandemic. Their study portrayed the current landscape of e-commerce in Vietnam, and offered insights into transforming online services to sustain e-commerce business and accelerate digitalization.

Bernabeo et al. reviewed literatures on AI in the aviation industry and discussed a roadmap for aviation AI in the context of Vietnam in chapter "Artificial Intelligence for Safety Related Aviation systems: A Roadmap in the Context of Vietnam". In their chapter, various applications of AI for aviation were examined, including autonomous flights, preventive maintenance, air traffic management optimization, and training for staff. This chapter further evaluated the feasibility and challenges of implementing AI for aviation in Vietnam, as well as compared the Vietnam's prospect of using aviation AI with that of other countries.

Chapter "Case Study: Utilising of Deep Learning Models for Fault Detection and Diagnosis of Photovoltaic Modules to Improve Solar Energy Constructions' O&M Activities Quality" presents another case study of AI implementation for

improving solar energy construction's operation and maintenance activities quality. In this chapter, Nguyen-Vinh et al. described in detail their attempt to employ deep learning technique for fault detection and diagnosis of photovoltaic modules to achieve the mentioned objectives.

Chapter "The Impact of Online Learning Facilities and Activities on the Effectiveness of Online Learning for Secondary Education: The Case of Vietnam" provides a unique perspective on the effectiveness of online education in secondary education in Vietnam. In this chapter, Tran et al. surveyed over 5,000 secondary school students from five different provinces in Vietnam, and they performed multiple regression analysis to examine the antecedents of online learning effectiveness. Their findings revealed that learning and teaching activities influenced the effectiveness of online learning to a great extent, whereas online learning facilities also impacted on effectiveness but to a lesser extent.

Chapter "Improve Information Security Awareness of Economics and Management Students" offers an important analysis of information security awareness of economics and management students in Vietnam. Based on survey data collected from 465 students, Nguyen et al. compared information security awareness between students who had received information security training and untrained students. Students receiving information security training demonstrated a higher level of knowledge, awareness, and information security behaviors, which highlighted the importance of the training.

In chapter "Analysis of the Material, Spiritual Needs of the Elderly and Attractive Market Opportunities in Vietnam", Nguyen and Nguyen analyzed elderly people's material and spiritual needs and identified attractive market opportunities to address those needs by using a mixed method approach. Based on interview and survey data, the researchers identified various needs which were grouped into three main categories: (i) health and medical products/services, (ii) specialized food for the elderly, and (iii) social interaction services and activities. The researchers further compared the current state and expectations and identified gaps in those categories of needs, as well as provided insights into the lifestyles and shopping behaviors of elderly people in Vietnam.

In relation to research on branding, Le et al. developed and validated a conceptual model to explain the antecedents of brand addiction and loyal behavior of consumers in chapter "Harmonious and Obsessive Passion Influence Consumers' Support for Technology Products Through Brand Addiction". The researchers analyzed data collected from 417 respondents, and found that harmonious and obsessive passions supported the consumer's brand addiction and subsequently led to their willingness to support a brand after a scandal. The research contributed to the current body of knowledge on consumer-brand relationships and provided practical recommendations for brand managers to take better care of their brand's consumers.

Finally, chapter "Explanation of a Sustainable Digital Transformation Process in a Firm" provided a qualitative case study that investigated sustainable digital transformation process over time in a telecommunication company owned by the state in Vietnam. By combining survey data and interviews with key informants, the researchers developed a framework to describe the sustainable digital transformation

at the company which consisted of three phases: (i) preparation, (ii) trial, and (iii) implementation. The study contributed to the literature on digital transformation processes and especially in the sustainability context, by identifying the influential external factors and their impacts on different stages of the transformation process.

## 4 Conclusion and Future Outlook

As technologies such as AI, cybersecurity, and digital transformation continue to advance and permeate every aspect of people's lives, IS research plays an important role in developing knowledge of how these technologies impact organizations, individuals, and society at large. The current chapter introduces nine chapter in the book Information Systems research in Vietnam (Volume 2), which seeks to address these emerging technologies. We invite readers to further read the detailed chapters for the insights on IS research and practice in Vietnam.

Regarding future outlook, sustainability has become a critical global concern which attracts tremendous attention from scholars, practitioners, and other stakeholders. Sustainable development practices, which include topics such as improving environmental performance, social responsibility, economic sustainability, and strengthened partnerships, are of increasing importance to organizations and societies [18]. Likewise, current discussions on emerging digitalization topics, including the adoption and appropriation of new digital technologies and digitalized processes, also put emphasis on sustainability issues [8]. IS research, with its multidisciplinary focus on the interactions between technology and humans, can contribute significantly to further our understanding of IS and their impact, especially in addressing sustainability goals. For instance, researchers could investigate IS-related phenomena related to data management, responsible behaviors and ethical considerations of individuals and organizations, transparency of supply chains, and circular economy models, to name a few.

Against this backdrop, we find abundant of opportunities for IS research in Vietnam. A National digital transformation program for Vietnam was issued by the Prime Minister in Vietnam on the 3rd of June 2020 [19], signifies the country's commitment to become a digital nation by 2030. As a result of this program, individuals, business owners, and government officials are encouraged and incentivized to embark on the digitalization journey together, via initiatives such as funding support and sandboxes for hi-tech startups, prioritized STEM training, and revised regulations for emerging technologies such as AI and blockchain. Similarly, Vietnam as a developing country is facing multiple challenges in terms of sustainability, including climate change, environmental degradation, and waste management. In response to the 17 sustainability development goals (SDGs) of the United Nation, Vietnam is committed to implementing the 2030 Agenda through taking practical actions such as enhancing institutional setup and policy frameworks for encouraging foreign and domestic investors to invest and conduct business in line with sustainable development principles. For instance, transparent reporting of corporate social responsibility

and sustainability practices was recently made a requirement for companies listed on the Vietnam's stock market.

Therefore, IS scholars are presented with the opportunity to investigate the digitalization processes and sustainability practices that take place at multiple levels in Vietnam, at their inception, and infused with the unique Vietnamese culture and context. Action research, design science, and other qualitative approaches would be particularly valuable and relevant for exploring highly contextual IS phenomena while generating research impact. We invite research collaboration from international scholars wishing to conduct IS research in Vietnam, and the Vietnam chapter of the Association for Information Systems (VAIS) will provide the venue to effectively facilitate such joint research endeavor.

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# Digital Transformation and Gender Representation: A Study of Service Advertisements in Vietnam

**Long T. V. Nguyen, Chi Nguyen, Thuy-Linh Le, Duy Dang-Pham, Phuong Hoang, and Rajkishore Nayak**

**Abstract** The digital transformation in Vietnam offers new opportunities for targeted advertising, but also enables biased and stereotypical content to be delivered quickly. Digital content can greatly impact public perception of gender roles and stereotypes, leading researchers to examine gender portrayals in digital ads for service brands in Vietnam. A content analysis of 300 digital service commercials found that female characters were more prominent than male ones and were often depicted in multiple roles. However, recent ads increasingly portrayed collaboration between female and male characters, and femvertising messages were conveyed more often. Despite these positive changes, gender stereotypes in digital advertising persist. This study highlights the need for policymakers and advertising professionals to consider the impact of gender portrayals in digital ads and strive for more balanced and non-stereotypical representations.

**Keywords** Digital transformation · Advertising · Gender inequality

## 1 Introduction

Marketing communication can be used to tackle social issues such as climate change, gender inequality, and women's empowerment [4]. However, since the 1950s, gender-role stereotyping has been a challenge for marketing communicators [10], with women often associated with domestic roles and men portrayed as powerful professionals in TV commercials [12]. Studies show that women are less represented in the media and are framed with inferior, dependent roles compared to high-rank professionals portrayed by men, especially in Asian countries influenced by Confucianism [22, 36, 38, 52]. In Vietnam, where women were educated to be dependent

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and obedient to men, gender stereotypes are still present, with women appearing as leaders in traditionally feminine roles [11, 52]. This persistent issue of gender inequality can negatively impact women's social status and limit their opportunities.

The technological advancement of digital platforms has made marketing communication more active and powerful in tackling social issues, leading to enhancing public perspectives in mitigating problematic ideology [25]. Some countries have witnessed a decrease in sexism and stereotyping portrayals in digital advertising following gender-related movements in society [9]. Non-stereotypical gender advertising has been emerging gradually in South Korea, where male actors endorse home products and female actors endorse masculine products [6]. In India, there has been a decline in stereotypical portrayals of women in advertisements throughout a period of 20 years in the twenty-first century, while gender-themed empowerment has recently emerged in advertising practices as advertisements provide self-empowerment for audiences, especially modern female audiences [44, 45]. Digital transformation has led to a drastic shift in the macro scheme of marketing operation towards digitalisation in Vietnam, leading to changes in the ways marketers and advertisers digitalise their marketing content regarding gender portrayals to increase customer engagement with the brand [7, 33, 39, 40].

Gender equality has progressed alongside economic development in Vietnam, resulting in increasing purchasing power, decision-making autonomy, and reductions in the gender wage gap [26, 30, 50]. Corporations have implemented initiatives for female empowerment, and advertisers are targeting women in the service sectors, but there is a lack of research on digital transformation in gender advertising in Vietnam [18]. Digital content has a significant impact on people's thinking, norms, and practices in the digital era, and advertising plays an essential role in reinforcing or mitigating gender stereotypes [3, 7]. Therefore, the emerging rise of digital transformation in service advertising in Vietnam could shape the understanding and practices of gender equality and inequality in the country. Hence, this study aims to answer the research question: How has the transformation of gender presentation been portrayed in Service advertising under the context of Vietnamese digital transformation?

## 2 Literature Review and Hypothesis Development

Vietnam has a long history that deeply embracing Confucianism culture to perceive women as the main caretaker (i.e. mothers and housewives) [50], and is considered as secondary to men [52]. While there are significant improvements in economic and social development, the country still experienced the inconsistency between the laws and reality for gender roles. Men here are usually symbolized as "the pillars of the house", and viewed at a higher social status [24]. Men also earn a higher salary and more job opportunities in the marketplace compared to their women counterparts [1]. While making up half of the labour force, Vietnamese women still struggle to find opportunities for promotions to executive levels [13]. A report from McKinsey highlighted that Vietnam ranked significantly lower than other neighbouring countries

in Southeast Asia when comparing the female-to-male ratio at executive levels with only one woman for every eight men [1]. Moreover, women are often paid lower as compared to their male colleagues at the same level, and are more likely to experience job elimination situations, especially during the pandemic situation [48]. Looking beyond the high concentration of women in the workforce, the Vietnamese market still witnesses gender pay gaps in all industries (average at 13.7%) [46], where men receive higher monthly earnings, including in Trade, Transportation, Accommodation and Food, and Business and Administrative Services [47]. Although this number is below the world's average (20.5%), the figures might be misleading since it does not account for unpaid work at home, which is still largely considered women's responsibility [46].

Moreover, women are often tightened to more entitlements and responsibilities in both domestic work and the workplace [24, 50]. The current perception of idealistic standards framed for Vietnamese women often requires a great balance between their full-time jobs and being family caretakers [52]. These double standards even became the guidelines for the public voters to select female candidates for the National Assembly and People's Councils [52]. Recently, Vietnamese millennial men have been more open to split the breadwinning role with their wives, despite primarily still perceiving it as the second income for the family [19]. Shifting mindset from traditional to progressive views in Vietnamese men to accept women as breadwinners are influenced by the media, family financial situation, and workplace role models [19]. However, through the pandemic, women have suffered much worse employment loss than men, including in Service industries like hospitality [54], hence, widening Vietnam's gender participation gap. While making up almost 60% of the hospitality industry, Vietnamese women suffered over 20% of working hour losses due to the pandemic [46]. The gender inequality is even more alarming among ethnic minority groups, with women and girls at high illiteracy rates, poor access to healthcare services, child marriage and teenage pregnancy [43]. There are some efforts in some businesses to address the issues. For example, Unilever Vietnam targeted disadvantaged women to support with microloans, business and leadership training, as well as healthcare, hence enhancing economic and social success [42]. However, gender inequality remains a social issue that requires attention from policymakers and business partners.

## *2.1 Advertising in Digital Transformation and the Gender Presentation*

Advertising has a significant impact on customer perceptions and behavior towards brands, especially in online spheres [15]. The omnipresent nature of marketing and advertising creates a relationship between consumers and companies, shaping public consciousness and culture [20]. Modern advertising media has expanded beyond just promoting functional benefits, with the ability to influence public perception

of broader social issues [5]. Traditional offline advertising has been overtaken by digital advertising, as customers spend more time on multimedia digital platforms and devices [29]. As a result, digital advertising has become one of the most effective methods to reach customers, with worldwide spending for internet advertising projected to reach USD 350 billion by 2024 [3, 40].

Advertising reinforces social and cultural gender stereotypes and expectations, leading to gender inequality [10, 14, 55]. Women are often depicted as primary caretakers, beauty and sexual objects, trophies, and less knowledgeable than men [4, 28, 31, 32, 44, 45, 49]. Several studies have categorized female stereotypes, showing the dependent and inferior status of women compared to men in advertising [32]. Gender portrayals in advertising have been discussed for decades, reflecting traditional gender's stereotypical roles, such as young, dependent parents, housewives, or sexual objects [44, 49]. However, these age-old concepts of gender roles are more explicit in product categories where men have higher purchasing power, due to the self-perception of masculine superiority and less acceptance of empowered women's roles [44]. Despite social movements to address gender inequality, commercials on both digital and traditional platforms seem to be behind the times.

## *2.2 Representations of Gender in Digital Service Commercials*

Workplace Gender Equality Agency categorized some Service sectors such as "accommodation and food", "financial and insurance services", and "rental, hiring and real estate" as gender-balanced industries [2] and, thus, where there is no significant gap between male and female representations [8]. However, the shares of Australian women working in these Service fields recorded slightly higher than their male colleagues, at 54%, 52%, and 39% respectively. Similarly, earlier research supported this gender-representation category list and further stated that finance, insurance, and real estate are ideal industries to witness more women presentations in both junior and senior positions. In the context of Vietnam, the development of the Service sector requires more women to join the workforce [46]. Furthermore, lots of social movements encourage women to be more independent and start their careers [54]. Since advertising media reflected the recent change in society [5], we predict that there are more female characters in Service commercials recently. It is hypothesized that:

*H1: Female characters are represented in Services commercials more often in period 2 (2018–2022) commercials compared to female models in period 1 (2012–2017) commercials.*

Confucianism Asian countries are majorily dominated by masculine cultures which strongly define gender roles in society [11]. In a Confucian country like Vietnam, it can be expected that women are more prominent in serving roles as the dominant

perception of Vietnamese people has been maintained quite consistently to place the serving responsibility on women [50]. As such, the magnitude of gender stereotyping can be visibly seen in any aspect of society [23]. In a cross-country study comparing Services commercials from Malaysia and Singapore, Tan et al. [41] found that women were more frequently portrayed in non-professional and family-related roles; moreover, in occupational settings, men were more frequently depicted in higher-level professional roles than females in lower-level positions. Khalil and Dhanesh [22] also noted gender prejudices in the Middle Eastern advertising sector where women were more frequently the main characters in serving role advertising. Therefore, we hypothesize that:

*H2: Female characters are more represented doing serving roles compared to male characters in commercials in both periods.*

Female employees are often portrayed in office jobs and administrative roles, whereas male candidates often appeared in high-skilled, technical, and outdoor jobs [13]. However, recent research highlights the rise of additional portrayal as a professional/expert role for female characters. Since it does not mean a reduction in the portrayals of other roles (i.e. caretakers), it might underline the additional responsibilities women are taking based on the multi-roles being represented in today's advertising. With the proven power to influence their users in conforming to certain gender stereotypes [31], we hypothesize that:

*H3: Female models represented in doing dual roles (both serving and professional/expert roles) are more often in period 2 commercials compared to period 1.*

Advertising professionals are becoming more aware of gender egalitarianism and equal gender roles as a result of movements for female empowerment in society at large. The longitudinal study in India by Tripathi et al. [44] revealed that starting in the middle of the examined period, men began to appear to work with women whether as the main characters or supporting characters. The findings also showed a more flexible gender role representation with role reversal; as a result, men were more frequently illustrated with collaboration and support for women and traditionally attached women's roles [44]. In Vietnam, Objective 5 of the National Strategy on Gender Equality in 2011–2020 highlighted that there are more media angles about the collaboration between men and women. The regulations enforce media and advertising practitioners to be aware of stereotypical gender roles and gender equality in their media products [46]. Thus, the appearance of collaboration between male and female characters will be expected in this study to appear more frequently in recent commercials. It is hypothesized that:

*H4: The collaboration of both female and male models is more often in period 2 commercials compared to period 1 commercials.*

Scholars have observed that the trend of women empowerment in advertising has increased due to socio-cultural shifts, such as higher educational standards and economic growth [16]. This trend is referred to as "femvertising," which aims to break social norms and barriers to allow women to control their own freedom and

make selections for their work and life balance [28]. However, critics argue that the values of feminism have been diluted and depoliticized due to commercialization [55]. The effectiveness of femvertising also depends on the context, as it receives mixed responses from the general audience and is more successful when targeting product categories where women are key decision makers [28, 44, 45]. Nevertheless, femvertising has gained more attention from marketers since the United Nations' 17 Sustainable Development Goals (SDGs), including SDG5, which aims to achieve gender equality and empower women and girls [48]. Given these factors, it can be hypothesised that:

*H5: The femvertising messages are conveyed more often in period 2 commercials compared to period 1 in all product categories.*

## 3 Methodology

This study collected digital service commercials with human models as the main characters from YouTube, which is the most popular video platform in Vietnam [21]. The commercials were delivered in Vietnamese through voice-over or subtitles and were published within the last 10 years (2012–2022) to ensure relevancy. The sample was divided into two periods (2012–2017 and 2018–2022) to investigate the evolution of the advertising landscape, with a focus on gender roles. Since the introduction of the SDGs in 2016, including SDG5 [48], marketing strategies and budgets have started to apply a "gender-empowered" theme. Therefore, we identified 2017 as a dividing point, as marketing strategies are often planned, and this year would have allowed for the new theme to be applied. The sample consisted of 300 digital service commercials with 406 main characters from 2018–2022 (Table 1).

This study used a coding protocol adapted from Prieler and Centeno [35]. Two research assistants were trained to code the commercials, with each coder coding half of the collected commercials under the supervision of the corresponding researcher. The coders identified central characters, the character's role based on their primary action, the collaboration between genders, and whether the commercials included femvertising.

**Central characters**. Central characters of the Services commercials were categorized as dichotomous variable: (1) male or (2) female. The criteria to identify if the

**Table 1** Number of main characters by investigated period

| Year | Central character | | Total |
|---|---|---|---|
| | Male | Female | |
| 2012–2017 | 63 | 59 | 122 |
| 2018–2022 | 119 | 165 | 284 |
| Total | 182 | 224 | 406 |

character includes six factors: central in the storyline of the commercials, longest appearance in duration throughout the commercial in close-up scenes, longest appearance in duration throughout the commercial in all scenes, giving a substantial amount of information or expertise about the advertised products or Services, interact with the products or Services (either by holding or using), and has extensive part speaking in the commercial [35]. This variable includes 122 male and 284 female characters as central characters.

**Roles of central characters**. The scale for roles these central characters play in the commercial was developed from constructs by Verhellen et al. [49]. The commercials were coded based on the activity or profession they portrayed, including (1) "serving roles" as the characters serving other characters without acting as professionals such as doing the domestic, parental or caregiving chores; (2) "breadwinner/expert roles" as the characters, including influencers having a proactive role in giving knowledge and expertise from their profession to the audiences, or portraying the role of the income provider in the family setting such as corporate leaders, office workers, freelancers, or small business owners; (3) "multiple roles" as the characters portray both mentioned roles in the same commercials; and (4) "others" as the leading character's role does not fall into either of the mentioned categories as demonstrated in Table 2. Central characters in the collected commercials were mainly portrayed as the breadwinner or experts and contributed to more than half of the total characters analysed.

**Cross-gender collaborations**. The variable, as portrayed in Table 3, includes the presence or absence of the collaboration between male and female characters in the TVCs that were coded as (1) not included or (2) included. There were a total of 37 characters portraying collaborating actions with characters having a different gender.

**Femvertising message**. The message of femvertising including encouragement for women to follow their dreams and passions, as well as become proactive or independent in making decisions was also coded as dummy variables (1) not included or (2) included. As illustrated in Table 3, femvertising messages were portrayed through 30 characters in the total sample of 406 characters. To analyse the data, percentages of each compared group in hypotheses are calculated along with the expected numbers

**Table 2** Number of main characters by the primary role portrayed in commercials

| Role of the central characters | Central character | | Total |
|---|---|---|---|
| | Male | Female | |
| Serving roles | 16 | 34 | 50 |
| Breadwinner/expert | 113 | 121 | 234 |
| Multiple roles | 10 | 15 | 25 |
| Others | 43 | 54 | 97 |
| Total | 182 | 224 | 406 |

**Table 3** Number of commercials including collaboration between male and female characters and inclusion of femvertising messages by the investigated period

| Year | Total number of characters | Collaboration | | Femvertising | |
|---|---|---|---|---|---|
| | | Included | Not Included | Included | Not included |
| 2012–2017 | 122 | 9 | 113 | 1 | 121 |
| 2018–2022 | 284 | 28 | 256 | 29 | 255 |
| Total | 406 | 37 | 369 | 30 | 376 |

which are means of the population. All hypotheses testing is carried out using chi-square goodness of fit by comparing the observed numbers to the expected numbers to reflect any significant differences.

## 4 Findings

Results from the data indicated that within the Services category, there was a significant difference between male and female representation as central characters in the commercials ($\chi^2 = 4.345$, df = 1, $p < 0.05$), in which female had a higher representation in the category. There were 224 females (55.17%) compared to 182 (44.83%) male counterparts in commercials collected from 2012–2022. These results supported Hypothesis 1 that females represent more in Services commercials than males. When reflecting on different periods, women's representation has increased in the later periods from 2018 to 2022. From 2012 to 2017, the representation of both genders is not significantly different ($\chi^2 = 0.131$, df = 1, $p > 0.05$), however, the rapid increase in women's representation after 2017 is significantly higher than men's ($\chi^2 = 7.451$, df = 1, $p < 0.05$) (Table 4).

In terms of serving roles in digital Services commercials, we hypothesize that there is a significant representation of women doing serving roles compared to male characters in commercials in both periods. The results indicate that there is a significant difference in gender representation ($\chi^2 = 7.053$, df = 1, $p < 0.05$). Specifically, females are more portrayed to do caregiving and serving works in the context of digital Services commercials with 49 characters (65.33%), while this number in male is 26 characters (34.67%). It means female portrayals are doubled in taking the

**Table 4** Gender representation as central characters in commercials between two time periods

| | Number of male central characters (%) | Number of female central characters (%) | Total | $\chi^2$ |
|---|---|---|---|---|
| 2012–2017 | 63 (51.64%) | 59 (48.36%) | 122 | 0.131 |
| 2018–2022 | 119 (41.90%) | 165 (58.10%) | 284 | 7.451* |
| Total | 182 (44.83%) | 224 (55.17%) | 406 | 4.345* |

* $p < 0.05$

**Table 5** Longitudinal analyses of female changes across both periods

| Variable | P1 (%) | P2 (%) | Chi-square[a] |
|---|---|---|---|
| Women with multiple roles (H3) | 40.00 | 60.00 | 0.600 |
| Cross-gender collaboration (H4) | 24.32 | 75.68 | 9.757* |
| Femvertising message (H5) | 3.33 | 96.67 | 26.133* |

[a] Degree of freedom for all chi-square tests = 1
* $p \leq 0.05$

serving roles in Services commercials compared to male counterparts. Therefore, hypothesis 2 is supported.

Hypothesis 3 predicts there is a significantly different representation of female characters doing both serving roles and breadwinners in period 2 commercials compared to period 1 commercials. Based on the result of the chi-square goodness of fit test, data did not support our hypothesis ($\chi 2 = 0.600$, df = 1, p > 0.05). Female characters are more represented doing dual roles as caregivers/servers and experts/breadwinners at the same. When comparing different periods, women's representation has maintained the same dual tasks regardless of the rapid increase in women's representation in commercials. These double tasks show that society (through commercials) still expects women in Vietnam to be good at caregiving tasks, while also excelling in office work (*Giỏi việc nước, đảm việc nhà*). A social movement for women's empowerment only succeeds in encouraging women to go to work but is unlikely to reduce the caregiving loads that they are expected to perform.

Hypothesis 4 proposed that the collaboration of both female and male models in Services commercials is significantly more often in period 2 commercials compared to period 1 commercials. The chi-square goodness of fit test resulted in a significant difference in the presence of collaboration between male and female characters in period 1 and period 2 ($\chi^2 = 9.757$, df = 1, p < 0.05). Thus, hypothesis 4 is confirmed. Although women are still prominently portrayed in domestic and caregiving works, there are more supportive roles of male characters in support of female characters in their works. Similarly, more female characters can collaborate with male characters in a traditionally male-dominated professional setting. This finding highlights some positive movements for the 'helping hand' between both genders in commercials which encourage both genders to share the load in the Service context.

The last hypothesis proposed there has been an increase in the number of femvertising commercials in the digital Services category in Vietnam. Our data analysis shows there is an increase of femvertising messages in digital commercials ($\chi^2 = 26.133$, df = 1, p < 0.05). There were 28 more Service commercials including femvertising messages in period 2 (96.67%) compared to femvertising messages presented in period 1 Service commercials (3.33%) (Table 5). This result correlates with the contemporary understanding of femvertising literature as a rising trend for brands with the association to brand responsibility in gender issues [5].

## 5 Discussion and Conclusion

This study examines the relationship between digital transformation and social movements in Vietnam, focusing on gender presentation in digital commercials. It offers a comprehensive understanding of the impact of gender presentation on customer perceptions of gender issues in Vietnamese society and contributes to the understanding of digitalisation in addressing social issues in emerging countries.

First, this research analyzed gender representation in digital commercials in two periods (2012–2017 vs. 2018–2022) and found a higher proportion of female characters in recent Vietnamese Services commercials. This trend can be attributed to the development of the economy and the Service industry, which create more job opportunities for women, as well as social movements promoting women's empowerment [30]. The finding is consistent with previous studies in Japan, the Philippines, South Korea, Hong Kong, and Japan, which reported a higher representation of female characters in Service-related sectors [35, 36, 38]. Despite such trend, gender inequalities persist in various sectors, and research on gender roles in Vietnamese advertising is needed [3].

Second, the study shows that Vietnamese women are predominantly depicted in serving roles in services commercials, reinforcing traditional gender norms of men as providers and women as caregivers [22, 37]. Although there are social movements aimed at reducing the caregiving load on women, these roles continue to target women in many Asian countries [27, 37]. In Vietnam, where gender roles are clearly distinguished in the public mindset, this further amplifies public perception of commercials, especially on digital advertising via social media platforms. Similar findings were observed in advertising studies from various contexts, with women portrayed in non-occupational roles in the United Kingdom, Malaysia, and Japan, and assigned to caregiving and familial chores more frequently than men [22, 27, 37, 49].

Third, regarding the positive changes in the dual roles of women to be both workers and homemakers in Vietnam, our findings do not confirm that. Economic development and digital transformation have strong impacts on women to free their family tasks to work freely in the marketplace. It results in a high percentage of women employment in Vietnam (above 70% women population from 1990 to 2022), and the characters are much higher than in other Confucian countries such as China, Japan, and Korea in recent years [53]. However, government social campaigns persuade women to join the labour force and to maintain traditionally enforced familial roles [17]. Both mainstream and commercial media portrayals keep highlighting that female professionals and leaders cannot become good women without the family aspects, in which Vietnamese women are always expected to excel at work without compensating for familial roles [51]. This discourse reinforces more pressure on women with doubled responsibilities and it is reflected through our findings in advertising digital commercials. As such, it is negatively remarkable when femvertising messages are misleading [28].

Fourth, our study shows improvement in cross-gender collaboration in Services commercials, promoting gender equality and collaboration through digital commercials. This indicates a change in the gender stereotype mindset in Vietnam, with initiatives to foster favourable attitudes and behaviours towards modern masculinity and femininity [18]. This supports a more supportive working mindset with women, including accepting women in masculine work and vice versa. A similar trend was observed in India, where Tripathi et al. [44] found a shift in gender roles in TV commercials.

Finally, the findings confirm that femvertising messages have been conveyed more frequently in recent digital Services commercials. This result correlates with the contemporary understanding of femvertising literature as a rising trend for brands with the association to brand responsibility in gender issues [5]. Based on the success of campaigns revolving around female-empowered corporate social responsibility [55], the subsequential result of the increase in femvertising practices are justifiable to win customers with higher awareness of gender issues and equal empowerment.

This study fills a theoretical gap by comprehensively understanding the role of digital transformation and digital advertising in addressing gendered issues. It provides a foundation for digital advertising professionals to develop a gender egalitarian mindset for future production. In Vietnam, marketers tend to represent genders, particularly more female characters in service sectors, following global advertising practices. The digital transformation landscape in Vietnam has led to a rise in consumption of female-based service offerings, such as beauty, skincare, fashion, and jewelry. This has resulted in a higher tendency to feature female characters in central roles in service commercials, to attract the attention of female consumers. The Services sector constitutes 69% of the consumption of online shoppers [34], making it essential for advertisers to cater to female consumers.

Social norms in Vietnam are still prevalent and reinforced by the digitalisation process, signaling the need for more progress in mitigating social discrimination and gender marginalization in the advertising industry. However, the Vietnamese government has implemented gender equality media legislation, which has resulted in a promising increase in feminizing advertising. In 2014, the Ministry of Information and Communications introduced gender-sensitive media indicators based on the UNESCO framework to promote greater gender equality in Vietnamese media [46]. As a result, femvertising practices in Vietnam have the potential to grow with increasing awareness among legislators, advertising professionals, and consumers.

The present study has some limitations. Firstly, due to the availability, the data collection was limited to the YouTube platform only while the digital advertising context in Vietnam has a wide range of other digital platforms (online newspaper, digital display advertisement on social media). Future studies could include the data from these platforms to provide more comprehenstive understanding of the issue. Secondly, the paper faced a noteworthy shortage of literature and knowledge of the issue in the local context, therefore the observation and interpretation from other countries' context may have the most suitability to explain the phenomenon in Vietnam. Thirdly, this study methodology is content analysis and, thus, can only review the secondary study, future research can explore the phenomenon from the

qualitative or quantitative perspectives of media consumers or advertising practitioners to comprehend the causes and results of such gender representation in Vietnamese digital advertisement.

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# E-Commerce and Digital Financial Services During COVID-19 and Potential for Expansion in Post-pandemic: Insights from Vietnamese Consumer Behaviors


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**Abstract** Despite the COVID-19 pandemic's negative and irreversible consequences on the global economy, e-commerce platforms and digital financial services seem to come out of the health crisis stronger. E-commerce and digital financial services in Vietnam have surged significantly during the pandemic and continued to expand in the post-pandemic economy. To understand how these changes translate into long-term industry reconfigurations and the potential for expansion in a new normal of contactless and convenience, this chapter focuses on analyzing the changes in consumer behaviors in this growing industry. Applying the content analysis to a qualitative survey collected across 5 major cities, we examine whether and how consumer behavior changes during the pandemic impact digital transformation in the retail sector. We show that there are promising signs of consumer interest in e-commerce can be sustained in post-pandemic and even potential for substantial growth. The preference for cashless transactions also helps to accelerate digital financial services. Thus, these are positive indicators for accelerating digital transformation in Vietnam.

**Keywords** E-commerce · Digital financial services · Consumer behaviors · COVID-19 · Vietnam

## 1 Introduction

COVID-19 pandemic, despite having many devastating and irreversible consequences on the global economy, e-commerce and digital financial services seem to come out of the global health crisis stronger with many prospects for expansion. During the pandemic, consumer habits have shifted from offline to online [14, 17,

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31]. The United Nations reported that global e-commerce soared to $26.7 trillion during the pandemic [34]. At the same time, the growth of e-commerce boosts the use of digital financial services [1, 19, 26, 36]. It is estimated that 70 million more people have purchased online in six Southeast Asian countries since the beginning of the pandemic [9]. The e-commerce industry in Vietnam is one of the fastest growing in the region and is expected to grow from $2.8 billion to $15 billion between 2018 and 2025 [12]. Ha et al. [13] find that there has been an increase in e-commerce and digital payment activities during the full or partial social isolation period to prevent the spread of COVID-19. Furthermore, there are signs that the changes in consumer behavior are sustained after each social isolation period. Interestingly, in another study, Nguyen et al. [23] reveal that consumers with high risks of infection, particularly the elderly, are more likely to increase online shopping activities. Thus, businesses and the government need to understand whether the unprecedented growth in e-commerce and digital financial services is sustainable in the new normal after the pandemic. This chapter provides an assessment of Vietnamese consumer behaviors and their adaptation to e-commerce and digital financial services during and beyond the pandemic. Our study attempts to provide practical insights for companies in terms of potential expansion of the customer base, and for the government to provide more transparency to the legal processes relating to the digital transformation of the retail and services industry.

Morgan [15] indicates that consumers worldwide have turned to e-commerce and digital financial services during the pandemic due to months of lockdown and social distancing. The greatest increase in the industry has been observed in emerging economies. The surge in online shopping in 2020–2021 in Southeast Asia has indicated a strong adaptation to the new way of life during the worst global health crisis in recent history. Consumers in this region have profoundly changed their behaviors, and in many cases for the long term. Online shopping has surged from an average of 5.2 platforms in 2020 to 7.9 in 2021 [9]. In Vietnam, the number of online platforms has increased from 5.7 to 8.2 [9].

Pre-pandemic statistics in October 2019 reported that only 2% of retailers in Vietnam had the majority of sales through e-commerce platforms. However, during the early months of 2020, the industry witnessed a record-breaking surge in the number of orders across various platforms. The 4 biggest B2C e-commerce platforms in Vietnam, namely, Lazada, Sendo, Shopee, and Tiki, have directly benefited from the swift changes in consumer behaviors. In addition to these big online shopping platforms, the rise of social media also connects consumers and retailers through channels such as Facebook and Instagram. Vietnamese consumers typically have a strong preference for cash transactions [32]. However, the pandemic has increased the volume of cashless transactions, as the fear that money can be a source for coronavirus transmission. With the support from the government to set the legal foundation for the fintech industry, there has been significant investment in digital financial services. There are currently 34 e-wallet platforms, including the top 5 in the industry, accounting for over 90% of the market share. The pandemic has contributed to expediting digital financial inclusion.

The current literature on e-commerce and digital financial services mainly focuses on changes in the industry that are driven by corporations, investors, and government regulations [3]. The understanding of e-commerce adoption from the consumer behavior perspective has recently been studied by Pavlou and Fygenson [26]; Zhang et al. [35]; and Ramirez-Correa et al. [28]. These studies identified indicators that have significant impacts on obtaining information and purchasing a product online, including skills, information protection, time and monetary resources, perceived risk, personal traits, and product characteristics. In this chapter, we focus on consumer behaviors to understand the factors that drive the unprecedented growth of the industry in Vietnam in the past two years and how the global health crisis changes the way we live beyond the pandemic. Specifically, we conduct a qualitative survey to examine the shopping habits, items purchased, health and safety concerns, type of payments, obstacles, technology readiness, and post-pandemic plan. The focus on behavioral science to understand the development of e-commerce and digital financial services is consistent with the research approach by the IS community in Vietnam [25].

The rest of the chapter is organized as follows. A brief literature review is presented in Sect. 2, followed by a discussion of the methodology and survey in Sect. 3. Section 4 provides the findings derived from content analysis. The chapter is closed with concluding remarks in Sect. 5.

## 2 Brief Literature Review

Although the long-term effects of the COVID-19 pandemic are not fully understood, we have witnessed its immediate and incredible impact on the retail industry [30]. To control the spread of the novel coronavirus, governments imposed strict restrictions, including lockdowns and quarantine measures. Most retail stores and services experienced temporary closure in 2020 and 2021, while the demand for essential goods such as groceries and healthcare products rapidly increased. Online shopping in the form of business-to-consumer (B2C) has become the primary channel for these products to reach consumers. To attract and retain customers, retailers try to find new approaches to selling products as consumption patterns of people have shifted from offline to online [17, 31]. Although online shopping was popular in many countries before the pandemic, COVID-19 has quickly led consumers to change their shopping habits and encourage them to choose online channels as their preferred means of purchasing goods.

Across Asia, the role of traditional wet markets has reduced significantly, and many shops and stores have temporarily or permanently closed. Hashem [14] indicates that COVID-19 had a strong effect on customer behaviors by increasing the tendency toward online shopping. In Taiwan, Chang and Meyerhoefer [4] find that the pandemic has increased the demand for online shopping services. Similarly, the COVID-19 pandemic has significantly influenced the online shopping behaviors of Vietnamese consumers [27]. In the study of Nguyen et al. [24] conducted in Hanoi,

nearly 80% of the respondents reported that they have engaged in online shopping more frequently during social isolation. Aryani et al. [2] report that sales of online distribution channels are rapidly increasing in India and Malaysia. Li et al. [18] find an increase in online shoppers from 11% before the pandemic to 38% during the initial stages of the outbreak in China.

Health and safety concerns are one of the main reasons for customer behavior changes during the pandemic [7, 8, 23]. Most people feel insecure when going out to physical stores that could be more prone to getting infected by the coronavirus [14]. Therefore, e-commerce has become the best alternative to purchase goods. A wide range of products and services with competitive prices and many promotions is another factor that pushes consumers to shop online [2].

In terms of products purchased during the pandemic, Hashem [14], Ellison et al. [8], and Svajdova [33] report that there was an overall increase in online sale volume of all analyzed products such as food, clothing, electronics, and healthcare items. Evidently, in Taiwan, the demand for food increased the most, especially for grains, fresh fruits, vegetables, and frozen foods. Similarly, the fear of getting sick encouraged higher frequencies of online shopping for healthcare items which is in line with the result found in Nguyen et al. [23].

During the pandemic, the growth of e-commerce also boosts the usage of e-payment due to its advantages such as convenience, health safety and security, easy schedule, and quick payment [29], and rewards and cashback bonuses [19]. These advantages have a positive impact on consumer behavioral intention to use cashless transactions [1, 36]. The increase in e-payments is supported by an increase in the relative rate of downloads of mobile financial applications which equates to 5.2–6.3 million applications downloaded daily from Google and Apple Store [10]. In Vietnam, Momo, Moca and Zalopay, Viettel Pay, and Air Pay dominate the mobile wallet payment sector [13, 20].

The increase in e-wallet transactions occurred not only during the pandemic, but the trend also continues beyond COVID-19 [36]. This trend is supported by Daragmeh et al. [5] and Ha et al. [13] which indicate that the new e-payment habits would be sustained in post-COVID-19. It has been shown that behavioral intention impact strongly on mobile wallet usage of Gen Y and Z, particularly in emerging economies like Vietnam [6, 20]. Technology readiness contributes significantly to the rise in digital service usage. A consumer with greater technology readiness is more likely to intensify or start using digital services. If the expectations of consumers are met and they perceive the benefits of cashless transactions, they are more likely to continue using digital wallets beyond COVID-19 [5, 19].

We have observed COVID-19's immediate and significant impact on the retail sector, but the question arises as to whether the change in consumer behaviors is temporary, or it will continue beyond the pandemic. According to Aryani [2], traditional shopping is hard to be replaced online shopping due to its advantages such as consumers having a better shopping experience as they could see, touch, and feel the products before making a decision. Grashuis et al. [11] report that consumers will return to brick-and-mortar shopping behavior when it is safe again. In contrast, other studies find that there has been a significant shift from physical shopping to online

shopping during the pandemic and it is expected to continue beyond COVID-19 [8, 14, 21, 31]. This chapter aims to provide insights from Vietnamese consumers and their behavior changes during the pandemic and in the post-COVID era.

## 3 Methodology and Survey

The primary data collected in this study is part of a larger study in 2020 in 5 major cities: Ha Noi, Hai Phong, Da Nang, Ho Chi Minh City, and Can Tho by Ha et al. [13] and Nguyen et al. [23]. In addition to 556 respondents participating in a self-administered quantitative survey conducted in July 2020, we also collected qualitative data from 92 participants in January 2021. In this chapter, we analyze the qualitative data using content analysis. By applying the qualitative method, we can further connect the empirical results found in Ha et al. [13] and Nguyen et al. [23] to provide additional insights into consumer behavior changes.

Initially, we distributed the online questionnaire to 50 people in each city in January 2021. All of them had done some e-commerce activities before and during the pandemic. We received 23 responses from Ho Chi Minh City, 20 from Can Tho, 18 from Ha Noi, 16 from Da Nang, and 15 from Hai Phong. There are more female respondents than males in the survey. The respondents are in the two prime working age groups of 20–29 and 30–39, 50% and 37%, respectively. The majority of the respondents are college graduates and postgraduates, and currently working in the private and public sectors. Monthly household income is at the high end of the range, 34% reported income from 10 to 20 million VND, and 32% reported income over 20 million VND. This reveals the high spending power of the consumers who participated in the survey. The pandemic, despite having a severe impact on the economy, 28% reported no change in income, and 40% reported a slight decrease in income. Overall, this reveals the resilience of the people and their productivity in a time of a serious health crisis and national lockdown. However, 30% reported a significant decrease in income, indicating a decline in the spending power of this particular group. In summary, the demographics of 92 respondents in this survey are representative of those who participated in a larger survey of 556 respondents conducted earlier.

The survey consists of 7 open-ended questions related to consumer behaviors as follows:

1. *During the social isolation period due to the COVID-19 pandemic, do you use more online shopping services? Please describe the changes in your shopping habits, e.g., what platforms do you use, what items are the main purchases, and do you use cash or digital payments?*
2. *Please state the main reasons for the change in your online shopping habits during the social isolation period.*

3. *Do you feel safe for your and your family's health when shopping online not using cash instead of buying directly from the store with cash? Please give examples and reasons.*
4. *Do you feel safe using your credit/debit card on e-commerce platforms? Please give a reason and explanation.*
5. *What obstacles do you have about shopping through e-commerce platforms, such as online shopping services, product quality, delivery services, product refunds/ exchanges, etc.?*
6. *Do you agree or disagree with the following quote: "I'm usually the first in a group of friends to use new technology products and learn by myself how to use new high-tech products and services without the help of others." Please give your explanation.*
7. *Do you plan to continue using e-commerce platforms for shopping after the pandemic? Please tell us why.*

These questions focus on the behavior changes during the full and partial social isolation periods between 2020 and 2021. The respondents answered each question in 10 to 30 words. We apply content analysis to analyze the changes in consumer behaviors during the social isolation period and prospects for continuing online shopping in the post-pandemic by coding the keywords from the answers provided by the respondents.

Content analysis is defined as a systematic, objective, and quantitative analysis of message characteristics. We apply the nine-step flowchart of content analysis described by Neuendorf [22]. We utilize the application tool NVivo to conduct the codification and verification and then calculate reliability for each key context. We use these results to predict the over-time trends of online shopping. The results are presented in Sect. 4.

## 4 Findings

Tables 1, 2, 3, 4, 5, 6 and 7 present the results derived from content analysis of the 7 open-ended questions in terms of the number of references and percentages. Table 1 provides a summary of the respondents' answers to question 1 in the survey. During the social isolation period, the number of references reported using digital payments was equivalent to using cash payments. This fact is an indication of a rise in digital payments compared to the pre-pandemic. One respondent confirmed this change in consumer behavior, "*I buy online from Tiki and Shopee. I do not use cash, I use an e-wallet*." With the percentage of bank account users remaining relatively low in Vietnam at 20%, digital financial services have the capacity to reach consumers across Vietnam as alternative sources of payment. For example, MoMo, one of the largest e-wallets in Vietnam, reported about 2 million transactions per day with a daily average of VND 520,000 per user at the peak of the pandemic. In terms of main items purchased online, 28% referenced food, followed by clothes and shoes,

13.4%. In terms of online platforms, the number of references to Shopee is the highest, followed by Tiki, 38.3% and 33%, respectively. This reflects the fact that Shopee is currently ranked the number 1 e-commerce platform, and Tiki is second in Vietnam according to Brand Catalyser.

Table 2 reports the main reasons for the change in online shopping habits during the social isolation period. The references to health and safety concerns are the highest, 38.1%, followed by social isolation and distancing, 26.5%, and convenience, 21.2%. The finding on health and safety concerns is consistent with the empirical results reported in Nguyen et al. [23]. A respondent confirmed, "*I feel safe when not in direct contact with many people, reducing the risk of infection*". Another respondent

**Table 1** Online shopping behaviors

| Payment methods | | |
|---|---|---|
| | Number of references | Percentage |
| Cash | 30 | 50.8 |
| Digital payments | 29 | 49.2 |
| Total | 59 | 100 |
| *Online shopping main items* | | |
| | Number of references | Percentage |
| Food | 23 | 28.0 |
| Clothes, shoes | 11 | 13.4 |
| Books | 10 | 12.2 |
| Cosmetics | 10 | 12.2 |
| Furniture, electronic products | 8 | 9.8 |
| Household products | 7 | 8.5 |
| Consumer goods | 4 | 4.9 |
| Medical products | 4 | 4.9 |
| Others | 5 | 6.1 |
| Total | 82 | 100 |
| *Online shopping platforms* | | |
| | Number of references | Percentage |
| Shopee | 44 | 38.3 |
| Tiki | 38 | 33 |
| Lazada | 13 | 11.3 |
| GrabFood | 6 | 5.2 |
| Company's website | 6 | 5.2 |
| Now | 4 | 3.5 |
| Facebook, Instagram | 2 | 1.7 |
| Others | 2 | 1.7 |
| Total | 115 | 100 |

**Table 2** Main reasons for change in online shopping habits

| Main reasons | | |
|---|---|---|
| | Number of references | Percentage |
| Health and safety concerns | 43 | 38.1 |
| Social isolation implementation | 30 | 26.5 |
| Convenience | 24 | 21.2 |
| Promotions, discounts | 9 | 8.0 |
| Variety of goods | 4 | 3.5 |
| Not available at pharmacies | 2 | 1.8 |
| Income change | 1 | 0.9 |
| Total | 113 | 100 |

**Table 3** Perceptions of health and safety concerns for switching to shopping online

| Health and safety concerns | | |
|---|---|---|
| | Number of references | Percentage |
| Feel safe | 73 | 82.9 |
| Do not feel safe | 15 | 17.1 |
| Total | 88 | 100 |
| *Reasons* | | |
| | Number of references | Percentage |
| *Feel safe* | | |
| Limit exposure to the virus | 50 | 89.3 |
| Convenience and fast | 5 | 8.9 |
| Protect the elderly | 1 | 1.8 |
| Total | 56 | 100 |
| *Do not feel safe* | | |
| Infected by delivery person | 7 | 58.3 |
| Infected from delivery of goods | 4 | 33.3 |
| Live in an unsafety area | 1 | 8.4 |
| Total | 12 | 100 |

expressed, "*I feel safe when shopping online because of convenience, less exposed to many people, and no cash transactions.*"

Table 3 provides the perceptions of health and safety concerns when shopping online. Overall, the majority of the respondents reported that they feel safe for their family when shopping online, 82.9%. Eighty-nine percent indicated they feel safe because of limited exposure to the coronavirus as confirmed by a respondent, "*I feel safer because of little contact with the sellers, payments* via *bank account are convenient without direct contact with cash.*" For those who reported that they do

**Table 4** Perceptions of safe and secure when using credit/debit cards on e-commerce platforms

| Safe and secure concerns | | |
|---|---|---|
| | Number of references | Percentage |
| Feel safe and secure | 48 | 52.7 |
| Do not feel safe and secure | 33 | 36.3 |
| Do not know | 10 | 11.0 |
| Total | 91 | 100 |
| Reasons | | |
| | Number of references | Percentage |
| *Feel safe and secure* | | |
| Security mechanisms to protect users | 13 | 51.2 |
| Reputation and prestige of online platforms | 7 | 29.2 |
| E-wallets/debit cards are safer than credit cards | 4 | 19.6 |
| Total | 24 | 100 |
| *Do not feel safe and secure* | | |
| Fear of fraud | 1 | 3.8 |
| Information security problems | 21 | 80.8 |
| Lack of multiple security mechanisms | 2 | 7.7 |
| Not all types of cards and platforms are safe | 2 | 7.7 |
| Total | 26 | 100 |

**Table 5** Problems and issues related to online shopping

| | Number of references | Percentage |
|---|---|---|
| Counterfeit and low-quality products | 46 | 45.1 |
| Exchange problems | 25 | 24.5 |
| Cannot check products before payment | 13 | 12.7 |
| Long delivery time | 9 | 8.8 |
| Poor customer services | 4 | 4.0 |
| Bad prepared in package and delivery of sellers | 3 | 2.9 |
| Payment Security problems | 2 | 2.0 |
| Total | 102 | 100 |

not feel safe, 58.3% indicated the reason for being infected by the delivery person "*because he/she also meeting other people before meeting me*," revealed one respondent. Thirty-three percent were afraid of being infected by the delivery goods as pointed out by another respondent "*I suspect the packaging process is not absolutely disinfected, and exposure at delivery is possible.*"

Table 4 reports that over 50% of the respondents revealed that they feel safe when using credit or debit cards on e-commerce platforms, while only 36% reported

**Table 6** Technology readiness

| Technology readiness | | |
|---|---|---|
| | Number of references | Percentage |
| Agree | 27 | 30.0 |
| Do not agree | 62 | 68.9 |
| Do not know | 1 | 1.1 |
| Total | 90 | 100 |
| *Reasons* | | |
| | Number of references | Percentage |
| *Agree* | | |
| Like to learn something new | 3 | 23.1 |
| Often buy and use new technology products | 3 | 23.1 |
| Follow trend | 1 | 7.7 |
| Total | 13 | 100 |
| *Do not agree* | | |
| Not interested in new technology | 9 | 21.5 |
| Need a guide, learned from friends | 9 | 21.5 |
| Depend on needs | 8 | 19.0 |
| Wait for the feedback and review | 8 | 19.0 |
| Others | 8 | 19.0 |
| Total | 42 | 100 |

that they do not feel safe using those cards. For those who mentioned it is safe, a general response is "*Bank cards have security mechanisms to protect customer information, I do not worry about this issue*." This explains the surge in digital financial services during the pandemic in the past two years. The National Payment Corporation of Vietnam (NAPAS) reported a significant increase in the number of transactions in interbank funds transfers during the social isolation periods [16]. For those who reported feeling safe, 51.1% referenced the security mechanisms to protect the consumers, while 29.2% indicated the reputation and prestige of the online shopping platforms. About twenty percent of the respondents claimed that e-wallets and debit cards are safer than credit cards. The respondents who reported that they do not feel safe using digital financial services on e-commerce platforms mainly referenced information security problems as the prime reason. Many respondents shared similar concerns as expressed by one individual, "*[I don't feel safe] because there is the possibility of hackers got personal information and accounts*."

In terms of problems and issues related to online shopping reported in Table 5, the references to counterfeit and low-quality products are 45%, while the references to product exchange/return are 24.5%. Other concerns, including cannot checking products before payment, bad packaging and delivery, taking a long time to deliver, payment security problems, and poor customer service. One respondent expressed

**Table 7** Plan to continue using e-commerce services after COVID-19 pandemic

| | Number of references | Percentage |
|---|---|---|
| Plan to continue | 81 | 88.0 |
| Do not plan to continue | 8 | 8.7 |
| Do not know | 3 | 3.3 |
| Total | 92 | 100 |
| *Reasons* | | |
| *Plan to continue* | | |
| Convenience | 37 | 60.7 |
| Save time | 9 | 14.8 |
| Safe for health | 5 | 8.2 |
| Habit and preference | 4 | 6.5 |
| Others | 6 | 9.8 |
| Total | 61 | 100 |
| *Do not plan to continue* | | |
| Prefer to shop directly in local stores | 4 | 80 |
| Still, buy fresh food in the market | 1 | 20 |
| Total | 5 | 100 |

the issues related to online shopping as follows: "*Product quality is sometimes far different from the ad I saw. Some vendors have no credibility. When purchasing a defective product, I can get a refund but must undergo a series of procedures and time-consuming so I did not want to return.*"

Technology readiness is one of the main determinants of the usage of e-commerce and digital financial services. In response to question 6 reported in Table 6, 30% of the respondents agree with the statement "*I'm usually the first in a group of friends to use new technology products and learn by myself how to use new high-tech products and services without the help of others,*" while 69% do not agree. For those who agree with the statement, 46% reported that they can learn new technology, 23% revealed that they like to learn something new, and 23% stated that they often buy and use new technology products. A tech-savvy respondent revealed that "*I always want to explore new technology. Each technology has its uniqueness, it is better to learn by oneself*." The main reasons for the disagreement are as follows: 21.4% revealed that they are not interested in new technology, 21.4% stated that they need to learn from friends, 19% wanted to wait for the feedback and review, and 19% said depend on needs.

Finally, the respondents were asked about their plan to continue using e-commerce services after the COVID-19 pandemic. Table 7 reveals that 88% of the respondents reported that they plan to continue using e-commerce services in the post-pandemic. This result is consistent with findings in other countries [8, 14, 21]. For those who plan to continue using e-commerce, the main reason is the change in shopping habits in the past few years as found in previous studies [17, 31]. Respondents who reported

that they are not planning to continue using e-commerce stated the main reason is a preference for shopping directly in local stores as found in other countries by Grashuis et al. [11] and Aryani [2].

## 5 Conclusions

This chapter provides the findings of a qualitative study using content analysis to complement the quantitative study conducted in 2020 in five major cities in Vietnam by Ha et al. [13] and Nguyen et al. [23]. In early 2021, we conducted a qualitative survey with 7 open-ended questions related to changes in consumer behaviors using the same demographic group in the quantitative survey conducted earlier in 2020. The findings from content analysis in this study provide strong supporting evidence confirming our results previously disseminated. Our findings are consistent with previous results in several ways. First, health and safety concerns are the highest priority of consumers during the pandemic. They are the primary reason for switching from offline to online shopping and the surge in the usage of e-commerce platforms. Second, there is evidence of a significant rise in digital payments compared to the pre-pandemic level, indicating the acceleration of digital financial services. Third, the majority of consumers feel safe when engaging in digital transactions. Last but not least, there is strong evidence that e-commerce and digital financial services could be sustained and expanded beyond the pandemic. The findings of this study are also consistent with previous studies on consumer behaviors in Vietnam during the pandemic [20, 24, 27]. Our findings on the changes in consumer behaviors towards online shopping also support the data that e-commerce platforms are the biggest gain during COVID-19 as reported by the United Nations [34].

The pandemic has influenced and forced consumers to adopt behavior changes that led to the expansion of e-commerce and digital financial services in Vietnam within a short period. Future research must strive to clarify the short- and long-term effects of the pandemic on consumer behaviors and its impact on the online retail sector and the fintech industry. This could be helpful to provide guidance to cope with those changes by transforming operations from brick-and-mortar stores to virtual shopping malls through accelerating digitalization [18]. In the post-pandemic era, enterprises must apply digital transformation to generate value for themselves and their customers to survive and grow. Our study provides insights from Vietnamese consumers to understand how their behavior changes could lead to the reconfiguration of the industry through accelerating digitalization and financial inclusion for future sustainable growth of the digital economy.

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# Artificial Intelligence for Safety Related Aviation Systems: A Roadmap in the Context of Vietnam


**A. Bernabeo, S. Goundar, K. V. Nguyen, B. N. Thien, Q. Luong, and M. N. Dinh**

**Abstract** In this chapter, we will review some of the Artificial Intelligence (A.I.) roadmaps to discuss the various implications of A.I. on the aviation sector and we will identify some high-level objectives to be met and the roadmap actions suggested to respond to the growth of Aviation in Vietnam after a comparison between Vietnam and other countries. In aviation, the possibilities of A.I. will increase due to the increase in the processing power of the computers. It will be used to make autonomous flights, preventive maintenance, A.T.M. (Air Traffic Management) optimization, pilots, cabin crew, ground staff, and airport staff training possible in a cost saving, less time consuming and less polluting way. Ethics International discussions on A.I. have intensified after Japan's G7 Presidency put the topic high on the agenda in 2016. The development in A.I. has international interconnections in terms of data circulation, algorithmic development and research investments. In this context, we will analyze this approach to the global stage as it is intended to build a consensus on a human-centric A.I. Through academic and professional expertise in the aviation and A.I. field, we intend to contribute to the needed high innovation capacity, skills and training development and management of A.I., supported by appropriate regulations and attention to ethical problems.

**Keywords** Airline operations · Air Traffic Management (A.T.M.) · Aviation · Artificial Intelligence (A.I.) · Expert Systems (E.S.) · Roadmaps

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## 1 Introduction

A.I. technology is a relatively old field of computer science that encompasses several techniques and covers a wide spectrum of applications. A.I. is a broad term and its definition has evolved as technology developed. Alan Turing, the British mathematician and scientist who first looked into computing intelligence in 1950, in his paper called "Computing Machinery and Intelligence", suggested using a now-famous 'Imitation Game' to test a machine's sentient capabilities, which eventually laid the groundwork for the development and discovery of A.I. Still, we may say that A.I. is defined as intelligence exhibited by an artificial entity to solve complex problems and such a system is generally assumed to be a computer or machine [1]. Intelligence, in simple language, is the computational part of the ability to achieve goals in the world. Intelligence is also the ability to think, to imagine, create, memorize and understand, recognizing patterns, making choices, adapting to change and learning from experience. A.I. is concerned with making computers behave like humans. A.I. tries to solve complex problems in a more human-like fashion and in much less time than a human takes [2].

Some of the early applications of A.I.-based technology have included image recognition systems, natural language processing and, while research in these fields continues, it is being used in several other applications. A.I.-based systems are currently being used for control and monitoring systems, financial analysis, medical prognosis, manufacturing, training, and scheduling. A.I.-based products that save the user time and money and outperform conventional software-based systems are currently being manufactured. Curran in 1992 stated that "it is likely that A.I. and E.S. technology will be used in the near future in at least two avionic areas".

The Vietnamese government is supporting the development of A.I. for the aviation community with initiatives that foster innovation and entrepreneurship. One example is the Vietnam A.I. Grand Challenge, a program launched in 2019 to encourage development of A.I. technology. It provides funding, support, and resources to A.I. startups and researchers, helping them to develop and commercialize their A.I. solutions. The possible benefits of using A.I.-based systems would include: Optimizing the use of airspace while meeting Air Traffic Control (ATC) requirements and reducing the cost of flying, Aiding the decision-making process of the flight crew, Aiding maintenance activity, Assisting data management, improving the Airport asset management.

## 2 Literature Review

The use of A.I. in Aviation Systems has been around for decades. A search on Google Scholar <www.scholar.google.com> using the key words "artificial intelligence for aviation systems" produces about 98,800 results (0.10 s). This indicates that research,

development, and applications of A.I. in aviation systems are insightful and applicable. A.I. and machine learning can manage the complex and often multidimensional problems faced within the aviation industry. Researchers Sangeetha et al. [3], conducted a study where they did a 32-year meta-analysis of A.I. research in aviation. Scholars, researchers, and practitioners, through their recommended guidelines, are encouraged to jointly develop a suitable environment for the implementation of A.I. tools within the aviation industry.

The use of A.I. within the entire aspect of aviation and flight operations was studied by Kashyap [4], which provides a framework for programmed control to guide flight routes, flight administration, A.T.M., aircraft engine diagnostics ontology, security, and safety of flights. The author suggests that A.I. technology is recommended for most operations of the aviation industry as it outperforms human capability in many aspect. In their chapter titled "Impact of A.I. in the Aviation and Space Sector", Liu et al. [5] focuses on applications of A.I. in airports, space, and general aviation. They add that the applications of A.I. in the aviation sector involve remote sensing, dynamic guidance, auto pilots, safety in aircraft maintenance, repair operations, fuel injection control, and fuel efficiency.

Literature search on A.I. for aviation systems indicates the usage of A.I. for A.T.M. as one of the most published articles and thus a widely used application. A.I. and eXplainable Artificial Intelligence (XAI) were used by EASA [6] to manage the complexity of A.T.M. systems. A.T.M eXplainable A.I. can use descriptive, predictive, and prescriptive models and synthesize them in a conceptual framework for future scenarios. According to Ross [7], "Flight Management System (FMS) is one of the key elements of the modern airplane". To manage an aircraft's navigation, guidance, flight control, aircraft positioning by data, and navigational aids, flight management systems use various A.I. algorithms. Conflicts might arise between pilots, airlines, traffic controllers and between traffic controllers (domestic and international) due to the variety of airlines and aircraft and the increase in the number of flights. These conflicts can be handled amicably by A.I. recurrent neural network [8]. An A.I.-based digital assistance system is proposed by Pham and Alam [8] to "detect conflicts in air traffic by systematically analysing aircraft surveillance data to provide air traffic controllers with better situational awareness". Similar research by Qu et al. [9] looks at "Cooperative Decision Making Under Air Traffic Conflicts Detection and Resolution". The authors present a few probabilistic methods for aircraft conflict evaluation. Their probability method enables considering the features of stochastic dynamics of motion and the new compositional method of conflict probability evaluation.

Simulations based on A.I. are used for different types of specialist training in the aviation industry. It is becoming common for pilots to be trained using virtual reality. Application of A.I. for operational meteorological information are presented by Sikirda et al. [10]. They also suggest the use of A.I. methods based practical courses for aviation specialists (pilots, air traffic controllers, operators of unmanned aerial vehicles, etc.). Machine learning, multi-criteria decision analysis, and text analysis as the methods of A.I. for air traffic controllers training have been described by Alkhamisi and Mehmood [11]. They developed a neural network prototype for

evaluating the timeliness and correctness of the decision-making process by air traffic controllers. Three types of simulation training exercises for CTR (control zone), TMA (terminal control area), and CTA (control area) with different complexity was analysed by Vasyliev and Vasyliev [12]. This has been used for pre-simulation training of specialists of air traffic services and includes four layers of the neural network model.

Apart from air traffic management, flight training, navigation, and auto pilot systems, A.I. has been used in predicting repairs required for aircraft components and parts. According to authors [13], "corrosion identification and repair is a vital task in aircraft maintenance to ensure continued structural integrity". Inspection of large areas visually in the fuselage by human inspectors is not only time consuming, but subjective. The authors propose a methodology for automatic image-based corrosion detection of aircraft structures using deep neural networks. They achieve precision of 93% and assist in case of inspector fatigue and lack of training. A systematic literature review by Pasiyadala and Rupesh [14] concludes that A.I. and advanced data analysis tools can be used to mitigate risks in the aviation sector. They looked at methods combined with proactive, interactive, and predictive measures currently being used to mitigate risks in the aviation sector for error tolerant systems. While ensuring that the components and parts on operating aircraft are in perfect condition, it is equally critical to consider the parts and components that are going to be used for new aircraft manufacture. Aviation manufacturing is at the leading edge of technology with materials, designs, and processes where automation is not only integral; but complex systems require more advanced systems to produce and verify processes. In their research, Dergachov and Kulik [15] argue that A.I. can reduce risks and allow complex processes to be less exposed and minimise internal errors in operations. The manufacture of aviation parts still relies on manual decision-making processes, process planning and a disconnect between process design and manufacturing. A general framework for twin data and knowledge driven intelligent process planning of aviation parts and components is proposed by Ostroumov and Kuzmenko [16]. Aircraft contain many components and parts, while the cockpit is a complex system of instruments, components, and controls. Aircraft operations are complex, and pilots require extensive training and while flying they need to perform an absolutely error free operation. For an aircraft to go from one point to the other, there are many risks involved. Risks can arise for example from the ground staff maintaining the aircraft, to the pilots flying the plane, the air traffic controllers instructing the airplanes' pilots for take-off and landing as well as all other aviation systems involved. A model developed by Chopra [1] exploits the ensemble of machine learning and deep learning algorithms to improve the prediction of risks and risks' severity in aviation systems. The model is trained and evaluated using twelve years of data from the Aviation Safety Reporting System (ASRS) database.

Apart from the above, A.I. has been used for flight emergencies [11], aircraft load optimisation [17], aviation cyber security [18], cockpit alerting system [19], autonomous aircraft motion [20], and flight delay prediction [21].

## 3 Characteristics of Aviation Systems Related to A.I. and Information Systems

Making operational decisions in aviation operations have been analyzed using physics-based models since aviation operations involve many decision makers and multiple objectives. Poor or unavailable physics-based models and a rich historical database are prime candidates for analysis using data-driven methods [22]. Integrating A.I., the use of Augmented Reality and the applications of Virtual Reality to aviation domain (Initial and Continuing Airworthiness, Maintenance, Air operations, ATM/ANS, Aerodromes, Environmental protection, Training, etc.) could offer remarkable assessment of A.I. introduction on system safety methodologies within a well-structured roadmap (Existing guidance such as ED-79A/ARP4754A; ED-12C/DO-178C).

In the aviation field, environment, connectivity and security current challenges of capacity can be overcome with the application of A.I. As highlighted in the Civil Air Navigation Services Organization (CANSO) Europe Vision 2035, CANSO believes that increased automation, service-oriented architecture, virtualisation and interoperability to transform A.T.M. performance is an important clear journey towards system-centric technology. Data-driven technologies like A.I. will be enabled by the digital transformation of the aviation industry which forms a critical part of the high-performance A.T.M. systems of the future. A.I. in aviation can also help to optimise flight plans, to improve turnaround times, thus reducing operating costs and at the same time helping to reduce pollution and fuel exhaust gasses emissions. A.I. is about exploiting the vast quantities of operational data available and using the data to identify cost savings to be made and improve future decision making. For example, while humans are very efficient at deciding which aircraft configuration type should be used on a particular single route, in case of an airline with different engine configurations, it is impossible for anyone to look at the pattern of flights for the entire day and see whether an aircraft is optimised for all its routes across the whole day. This can be done by already developed A.I. tools. Flight operations staff can benefit of this A.I. tools recommendations and then they can decide on whether to accept the recommendation. Millions of USD every year can be saved using A.I. tools to optimise aircraft allocation.

Key to the success and usefulness of A.I. includes developing human-centered automation and designing advanced technology that will capitalize on the relative strengths of humans and machines. For example, expert advice in a timely manner can take advantage of E.S. Factors such as stress which impairs human decision making do not influence ESs. Recognizing pre-failure signatures in airborne machinery which are difficult to control with conventional techniques, or are difficult to model, is an excellent application for this particular field of A.I., e.g. Fuzzy logic systems, which are useful for applications that normally require human intuition. Verification and Validation (V&V) methods for A.I.-based systems are one of the primary activities that requires addressing by developers and certification specialists' concerns. In this chapter, numerous V&V techniques that have been successfully applied to ESs are

identified. It will be a challenge identifying a set of tests that can be demonstrated to satisfy safety requirements.

Research investments, algorithmic development and data circulation, considering the international interconnections of A.I. development in terms of, are the areas where we will: identify the operational environment in which the A.I.-based (sub) system will be used; human resources, and equipment, including hardware and software combined procedures will be discussed, organised to perform a function within the context of ATM/ANS and other ATM network functions, also including optimization of pilots, cabin crew, ground staff, and airport staff training. A human-centric A.I. approach to the global stage is intended to build a consensus that can be applied to four classes of functions. These are: Sensing and registration of input data Information acquisition: Supporting human sensory processes that involve operations equivalent to the first human information processing stage, including cognitive functions such as working memory and inferential process information analysis; Decision-making involving selection from among decision alternatives; Actual execution of the action chosen by reference to action implementation.

## 4 Artificial Intelligence and the Aviation Developments

### *4.1 A.I. for Planning and Forecasting in Aviation Industry*

Informed business decisions and data-driven strategies can only be delivered through significant analysis processes, one of which is forecasting, which generates key inputs for companies for planning. The businesses within the aviation industry need accurate and informed forecasting, especially considering pandemic crisis downturn. Here, external factors such as growth in incomes, changes in transport prices and demographic changes reflect the aim of forecasting that is to determine how patterns of demand will change over time. The need for airport facilities including airline passenger terminals and aprons, air cargo buildings and aprons, the number of taxiways, runways, etc. will be suggested through forecasting of unconstrained aviation activities such as the number of airline passengers, the air cargo weight, the fluctuation in cargo airline operations, or just general airport operations.

Forecasting basic concept is to analyze past trends and project them forward to the planning timeline. Xu et al. [23] propose a hybrid SARIMA-SVR model to forecast statistical indicators in the aviation industry. More specifically, Wargentin [24] describes a time-series techniques to forecast passenger demand both in long and short term at the Airport of Bologna (Italy). In the short-term forecast, the time-of-week passenger demand was forecasted using two non-parametric techniques: local regression (LOESS) and a simple method of averaging observations. In the scope of this review, we suggest that more complex ‘causal’ forecast techniques, in which forecast values are constructed by looking at a combination of historical

relationships between variables such as GDP, population, travel costs, consumer spending, are needed.

We consider forecasting capacity as an essential function for assessing the future demand for air travel in Vietnam. This assessment in turn, delivers a quantified view of what additional runway or airport capacity might be required in Vietnam to accommodate the growing numbers of air passengers in this country.

## *4.2 A.I. for Security and Safety in Aviation Industry Factors that May Lead to Injury or Loss*

Aviation safety refers to ensuring airplane passengers are free from factors that may lead to injury or loss. However, there are many more factors that need to be considered when it comes to aviation safety. Intelligence gathering, pre-boarding procedures and airport security personnel are amongst those factors where aviation security can be considered the most relevant one.

As security requirements have intensified considerably in recent years, they also present challenges for airport operators to increase the efficiency of the operational aviation process. This is where advanced technologies could be helpful. According to Allied Market Research, the global market for A.I. in aviation is projected to reach $5,826 million in 2028 [25]. In this domain, A.I. technologies could help to optimize situational awareness with automated video monitoring including baggage monitoring, perimeter protection, control unauthorized entries, and automated foreign object debris (FOD) detection. Technologies such as those developed by Scylla [26] transform passive cameras into proactive security systems for real-time recognition of security threats.

When it comes to detecting signs of terrorist activity, human involvement is a must. However, the capacity is not scalable, and sometimes clumsy and confusing. Here, A.I. algorithms could be used to monitor the entire airport area constantly, especially in identifying and tracking suspicious objects or persons. For example, operational process and passenger flow at airport security checkpoints could be improved greatly with technologies such as the Open Threat Assessment Platform [27].

## *4.3 Cargo Handling*

Among various cargo transportation modes around the world, air cargo has been considered as one of the main ways to carry tons of goods at high speed across the globe and played a vital role for the economy's survival of a nation [25]. The Air Transport Association (IATA) shows that only in the U.S (United States), the Air Cargo sector rose 18% compared to 2018 levels [28]. It is crucial to keep up the efficiency of the agile air cargo handling processes to respond to the growing

business demands. Over the last few years, A.I. has been integrated into Air Cargo systems with many advantages in saving time, space, resource, and cost, which is able to reduce the inconsistency due to the manual intervention in cargo operation [25]. Some main implementations of A.I. in Air Cargo systems include cargo load planning [29, 30, 36], automated container handling [28], predictive maintenance in air cargo system [24], and decision making for cargo system [23]. Within limited time for all operations at the airport, these implementations aim to ensure efficient operations and minimize costs.

## 5 Aviation Artificial Intelligence Roadmap in Vietnam

### *5.1 Artificial Intelligence and Current Aviation Applications*

One of A.I.'s main advantages is its ability to automate many routine and manual tasks, freeing up valuable human resources for more strategic and creative work. From manufacturing and logistics to healthcare and finance this will certainly improve efficiency and productivity in industries. In addition, to better analyze data and to make more informed decisions, A.I. can also help companies, leading to improved outcomes and higher profits. In the Vietnamese tech sector, A.I. is already creating new job opportunities. Data science, machine learning, software development, and more areas where the demand for A.I. expertise grows, means an increased need for trained professionals. Economic growth and innovation in this sector will provide new career paths for young people.

As a sector, aviation and A.T.M. stands to benefit significantly from A.I as it is ideally placed to take full advantage of A.I., in particular in machine learning by virtue of its reliance on repetitive activity—which lends itself to analysis and machine learning. Since flight planning, flow management, safety assessments and conflict prediction complexity is embedded in the driving factors that deliver safe air traffic control, A.I. will be beneficial in these areas also. 'Big data' is a prerequisite for the successful use of A.I. since ATM is powered by air to ground and ground to ground data flows. Air Traffic Control (ATC) is a vast and enormously complex domain which is performed in a centralized way to monitor, manage, and modify trajectory of each aircraft to ensure the critical safety of all flights under any circumstances while getting them safely to their destinations [31, 38, 39]. Meanwhile, ATC aims to use efficiently different resources available such as the airspace, the air routes, the airport, and the runways. Moreover, ATC must also maintain different backup plans to ensure safety for unexpected scenarios [32]. There are also some new interrelated challenges: environmental improvements, energy transition, fuel efficiency, plane transferring between sectors, capacity flexibility, sequence of landing (Fig. 1).

The competences of A.I. in ATC should be able to contribute to effective systems addressing all these challenges. AI implementations help to make rapid judgments and eliminate human labor, which has been declared effective in providing timely

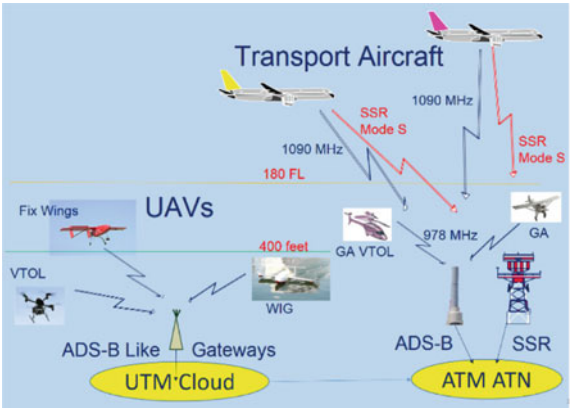


**Fig. 1** Surveillance concept for unmanned aerial systems traffic management (UTM) to air traffic management (ATM). *Source* Lin, C. E., Shao, P. -C., Lin, Y. -Y. (2020). System operation of regional UTM in Taiwan. *Aerospace, 7*, 65. https://doi.org/10.3390/aerospace7050065

decision-support guidance in a variety of real-world situations of ATC [26, 37]. Some current breakthroughs in ATC using A.I. are automation transparency, airline delays, air traffic prediction, air traffic reduction. Liu et al. [5] tried to improve the accuracy and robustness of the air traffic prediction using a recurrent convolutional neural network which focuses on the spatial and temporal air traffic transitions. Meanwhile, an A.I. based approach to classify strategic, scheduled flights as delayed or cancelled is proposed in Degas et al. [33, 41]. This information is then used for proposing an optimization model for slot allocation. Luo et al. [18] proposed a hybrid prediction model using deep forest ensemble learning to analyze some common traffic control actions. The model aims to help the traffic controllers mimic the decision-making procedure by providing them with advanced control actions. Another prediction model of planning controller is studied in Garcia et al. [34]. Under a given traffic scenario, a supervised learning algorithm is modeled to predict the actions of the planning controller with the input of the aircraft 4D trajectory features. Indeed, A.I. and machine learning are already contributing to a wide spectrum of value opportunities in the aviation/ATM industry, from efficiency-focused to safety critical applications [40]. Supporting air traffic controllers (ATCOs), pilots, airport operators, flow controllers or cybersecurity officers are areas where A.I. has huge potential for use since it can reduce human workload or increase human capabilities in complex scenarios. New ATM/U-space services are also areas where A.I. will play a fundamental role in driving the development of new airspace users (high-level vehicles, low-level drones) further complexify the existing use of airspace (Fig. 2).

New conflict detection, traffic advisory and resolution tools as well as cyber resilience are areas where A.I. will also increase safety. The aviation/ATM industry value chain transformation, as aviation actors increasingly embark on digital transformation journeys, will benefit of A.I. which represents a potential breakthrough technology. In particular, helping both tackle capacity and environmental impact—the twin major challenges facing aviation today—will need a better use of aviation data leading to more accurate predictions and more sophisticated tools, increased

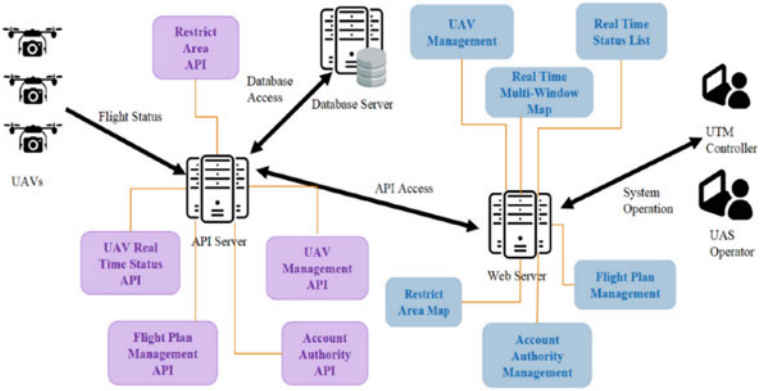


**Fig. 2** UTM system structure for tests. *Source* Lin, C. E., Shao, P. -C., Lin, Y. -Y. (2020). System operation of regional UTM in Taiwan. *Aerospace, 7*, 65. https://doi.org/10.3390/aerospace7050065

productivity and enhanced use of scarce resources (e.g. airspace, runways, staff): A.I. will enable this.

In the sector of flight crew, the number of avionic systems in the cockpit and the related amount of data that crew members must absorb has increased due to the expanding complexity. A.I. can help reducing pilot and information overload. The final system interface, as with any technology, (i.e., man–machine interface), needs to be an integral part of the design and development cycle.

The next operational area that can be targeted is Predictive maintenance, recommending the airports where it is needed to carry a stock of spare parts and optimising the location of both parts and engineers to see if they can introduce more predictability into our maintenance operations. The system wide information management (SWIM) protocol data should be shared across the organisations and feed other data sets into it: this can be seen as a step in the right direction towards improving integration of operations and safety. Machine-learning tools should better be based on a cloud.

Greater security to protect our data though Cloud hosting gives the scale and reliability needed. Small, frequent, continuous improvements and on finding small solutions and removing the bottlenecks will also be supported through A.I.

## *5.2 A.I. in the Airline Operations-Characteristics of Aviation Systems and Related It to Information Systems*

Aviation technology is critical for the industry to improve the customer safety and sustainability. The aircraft system must receive the special care to deliver the safe flights, in addition to the care and maintenance of the aircraft's engine, propeller, as well as the pneumatic system (Fig. 3).


**Fig. 3** A.I. in the airline industry: applications in the 10 areas of the airline industry. *Source* https://www.altexsoft.com/blog/engineering/ai-airlines/

There are several areas A.I. can be used in the airline operations including the 10 following aspects:

The first aspect is the revenue management. This refers to the use of data and analytics to define the way to sell products and services to the potential customers at an affordable price, at the right timing and channel. As an example, in the Vietnamese context, the manufacturing of processors is set to play a significant role in Vietnam's AI landscape. Backbone of A.I. systems, such as processors (i.e., Central processing units (CPUs) and graphics processing units (GPUs)), and their production is essential for the growth of the AI industry. Demand for processors as the demand for smarter and more advanced devices is growing. In Vietnam, companies like Intel have been investing in the production of processors for years. The continual improvement of the quality of processors being produced will be another area where A.I. will play a critical role in this growth, as it will help to optimize the production process. As processors are in high demand globally, this will create jobs and will generate export revenues. The second aspect is about air safety and maintenance of aircraft. Because of frequent problems occurring in the airline industry such as delays and cancellations, airlines face high costs. These costs not only cover the maintenance cost, but also the compensation costs for travelers who are stuck at the airports. As the result, it is essential for the experts to conduct predictive analysis for the delay time which is rooted from the unplanned maintenance. The AI technology is adopted in the airlines in the way that predictive maintenance measures are executed for the better data management of airplane health monitoring sensors. As the result, the airplane staff can more rapidly receive updates on the maintenance operations, data on expenses, and inventor through different dashboards [29].

The third application is feedback analysis. Airliners are always aware of the constant improvement of customer service. Therefore, A.I. is used in the feedback analysis plus market research can help the airplane industry come up with informed decision, as well as satisfying the demand of customers. For instance, by establishing a business analytics platform called the Automated Neural Intelligence Engine (abbreviation for ANIE), the airline can conduct the data review, classification, visualization, and perform sentiment analysis. As such, the A.I. system allows the airlines

to decide which touchpoint in the customer journey should be improved to turn poor into good experience [29].

The fourth application is messaging automation. A fact is that in many cases of flight delay, and loss of baggage, if the customers are not informed timely, they will get anxious. Therefore, the AI software is applied to speed up the workflow of customer service. Namely, the software will use algorithms to process the natural language as well as unstructured text. Alternatively, the chatbot application can be used to support the customers to book, manage flights, track luggage, respond to customers' queries and other types of assistance.

The fifth application is crew management. Every day the crew is allocated with multiple tasks, and the task allocation must ensure to be free of conflict among pilots and the flight attendants. The task allocation is impacted by a number of factors such as the route of flight, licensing and qualification of team, type of airplane, fuel use, vacations, and work rules, etc. therefore, the AI will support the schedulers to integrate data from multiple sources such as traveler data, maintenance data, and onboard sensor data so that the will build up a full scenario of daily operations [29, 41].

The sixth application is optimization of fuel efficiency. The statistics show that the world aviation generates approximately 2% of the $CO_2$ emissions. Thus, the manufacturers have tried to reduce such rate. This not only relates to environmental issue but also financial motive that force the $CO_2$ reduction via using technology. The AI system with built-in machine learning algorithms to gather the flight data for the analysis in consideration of route distance, type of airplane, and weather, etc. Based on these, the system can make a rough estimation of the optimal fuel for that flight [35].

The seventh application is about the sales and food supply inside flights. By using A.I., the expert of supply management can calculate how many snacks and drinks they need to serve the customers during flights to avoid wastes [29].

The eighth application is detecting fraud. Many flights have to compensate a lot for fraud which has been increasingly sophisticated. As the result, the AI technology should be integrated to enhance client authentication, payment security, etc. by processing data from many sources to spot fraud. The A.I. can also find out possible revenue leakage and implement immediate preventive solutions [29].

The ninth application is the improvement of in-airport self-service. Particularly after the coronavirus pandemic, the requirements of contactless technology are very popular. As such, the airports and aircraft have performed self—service, and end—to—end solutions to bring the highest convenience for the passengers. The A.I. technology can support since they use smart systems to embed biometrics technology for the passenger verification. Another example is the BagsID, the luggage identification solution to detect bags of the customers based on their unique physical features [35].

Last but not least, the tenth application of A.I. in the aviation industry is flight management as well as autonomous taxi, takeoff, and landing. A.I. platforms can make the advantage of real time data which are collected from various sources and sensors to aid flight management and flight route optimization [29].

### *5.3 Aviation A.I. Feasibility and Challenges in Vietnam*

Europe has considered to keep pace with other actors which are leading the way in A.I. development, in the global race to achieve a crucial advantage in innovation, which is why the European Union has declared A.I. to be a major strategic priority. A.I. developments should also be safe, secure, human-centric, ethical, and trustworthy and support the core values of the EU.

In Vietnam, at the 2019 Vietnam Artificial Intelligence day (AI4VN) held in Hanoi on August 15, 2019, Bui The Duy, Deputy Minister of Science and Technology mentioned that a shortage of resources as well as a modest number of A.I. firms have been the biggest challenges for the development of A.I. in Vietnam. He noted that Vietnam has a lot of work to do in developing AI. We should pay attention to training human resource and creating data systems. Hoang Minh Son, principle of the Hanoi University of Science and Technology (HUST), said that organisations and individuals in Vietnam have studied A.I. separately without having an ecosystem.

In Vietnam, by connecting relevant parties in institutes, universities, businesses, tech groups and start-ups, AI4VN is expected to create momentum for the development of A.I. "A.I. could be used in many sectors such as healthcare, education, business, trade, finance and agriculture", he said. New applications to predict and monitor agricultural productivity, food security and infrastructure access in developing countries have been shared by Associate Professor Stefano Ermon from Stanford University. Economically reliable predictions when using high-resolution satellite images utilize also these methods. Global poverty reduction efforts can also be revolutionized.

## 6 Conclusion

In conclusion, the aviation industry is a critically complicated and big industry that requires constant application of the most advanced technology to maintain the safety for everyone. A.I. should be adopted in the aspects aforementioned so that it can bring the best comfort for the passengers and optimize the aviation operations.

We have presented all affected domains of the Aviation sector where A.I. can be applied and we suggest the following in the Vietnamese context.

To identify: the needed internal digital capacity, including skills, practices and training needs for impacted staff that support the AI adaptability in the face of new technologies; a number of areas in which further research is necessary toward efficient and practicable means of compliance with the defined 'A.I. trustworthiness' objectives in Vietnam; how this may impact the Aviation sector in Vietnam in terms of organisation, processes, and regulations; and the courses of action that the Aviation sector in Vietnam should undertake to meet those challenges. In the aviation sector, it is important that the development of A.I. remains within the framework of the high-level guidelines developed by the Ministry of Transportation, CAAV, etc. Those

guidelines are to be made known and applied by the Vietnamese aviation industry by the Agency which should also provide a feedback to the Ministry of Transportation.

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# Case Study: Utilising of Deep Learning Models for Fault Detection and Diagnosis of Photovoltaic Modules to Improve Solar Energy Constructions' O&M Activities Quality

**Khuong Nguyen-Vinh, Quang-Nguyen Vo-Huynh, Khoa Nguyen-Minh, Minh Hoang, and Surender Rangaraju**

**Abstract** Renewable energy sources have long been considered to be the sole alternatives to fossil fuels. Consequently, the usage of PV systems has experienced exponential growth. This growth, however, places gargantuan pressure on the solar energy industry's manufacturing sector and subsequently begets issues associated with the quality of PV systems, especially the PV module, which is the systems' most crucial component. Currently, fault detection and diagnosis are challenging due to many factors including but not limited to requirements of sophisticated measurement instruments and experts. Recent advances in deep learning have proven its feasibility in image classification and object detection. Thus, deep learning can be extended to visual fault detection using data generated by electroluminescence imaging instruments. Here, the authors propose an in-depth approach to exploratory data analysis of electroluminescence data, as well as several techniques based on both supervised and unsupervised learning to detect and diagnose visual faults and defects presented in a module.

**Keywords** Computer vision · Supervised learning · Unsupervised learning · Deep learning · Neural networks · Solar farm · O&M

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# 1 Introduction

The operation and maintenance (O&M) of solar farms is an essential duty that cannot be overlooked to maintain asset functionality. Concerning the return-on-investment, investors are highly critical. Failures or unexpected deterioration issues will result in lower energy production and a possible loss of component warranty due to manufacturer turnover if they go undiscovered. To maximize solar energy production, all PV panels and other associated components must function properly. The ability to produce electricity and maintain efficiency of a single panel is serious unsupervised learning hampered even as one of its cells is damaged [1]. The O&M services must ensure that solar energy is produced to protect investors' investment and interests.

Certain renewable energy harnessing product designs are exceedingly intricate that they require machine-like accuracy that human personnel are unable to provide. Modern technologies including Internet-of-Things (IoT), artificial intelligence (AI), robotics, and drones can lower the monitoring cost and promote efficient O&M services [2]. Data is gathered using state-of-the-art AI tools. The installation of IoT device on the solar panels also facilitate the collection of vital information. Automation with the help of robots and AI offers a quicker and more effective means to do various tasks to enable resources saving. Several hardware improvements, such as novel gate drivers, have been applied and by employing AI, and IoT more frequently, renewable energy companies can initiate a complete swing away from unsafe energy sources (e.g., coal and oil) in favor of solar energy [3].

# 2 How AI Was Integrated into O&M Activities of the Solar Energy Systems

## *2.1 Background*

Many solar power facilities do not have effective O&M systems. As a result, they frequently lose power that has already been generated. Modern technologies like IoT, AI with data learning, robotics, and drones can lower the monitoring cost and facilitate effective O&M services [2].

## *2.2 Literature Review*

To stay abreast of market demands, O&M contractors are increasingly dependent on innovations and data-driven solutions. The levelized cost of electricity (LCOE) is expected to decrease as a result of innovations in O&M services [4].

The most popular deep learning algorithm that is successful for image-based diagnosis by far is convolutional neural network. A study carried out by Shin et al.

[5] utilized the same deep learning algorithm to process images and detect faults. The crucial elements needed for defect diagnostics are automatically extracted from an image by this method. With enough training data, multiple failure modes can be learned, and the AI model can assess whether a problem exists on an undiscovered image.

Predictive maintenance is generally less effective due to high customization costs, the requirement for collecting a large number of physical variables, and the lack of a reliable Internet connection on solar farms. Additionally, the lack of a predictive component in the maintenance strategy makes it more difficult to reduce downtime costs. Statistical approaches based on data mining are now emerging as a very promising solution both for failure prediction and early detection in PV panels to keep implementation costs and model complexity down [6]. While manual diagnostic of PV panels is the least expensive option, its detection accuracy is the lowest. Predictions with the help of data and machine learning is reasonably priced and offer good detection accuracy [7].

A study carried out by Huuhtanen et al. [8] indicates that when utilising CNN methods there is a deviation in fault identification in PV panels. Hence, they propose numerical tests to show the exact power curve of a working panel. Their proposed method performs better than current methods relying on basic interpolation filters. Additionally, they develop an algorithm that uses power measurement history data (time series of power measurements) of a target panel and its surrounding panels to identify defective PV panels.

Another study demonstrates potential applications of AI to forecast PV energy generation. The proposed method is intended to serve as a module for the energy management and production scheduling of a photovoltaic power plant. The goal of the study was to create a solution that would help to deliver power efficiently based on historical and present-day data on solar radiation in real time. Different feedforward neural network designs and data input scenarios were examined, and the results provided a solution utilizing artificial intelligence to man-age photovoltaic energy production [9].

Compared to any conventional method, AI algorithms have the potential to provide better, quicker, and more useful predictions of PV panel failure. Artificial neural networks, fuzzy logic, adaptive network-based fuzzy inference systems, and data mining are some of the fields of AI [10].

In the planning and improvement of renewable energy systems, AI plays an increasingly important role. Numerous AI techniques and technologies are currently being widely used in the energy industry in areas including generation forecasting, energy efficiency monitoring, energy storage, and overall energy system design [11]. Currently, complex algorithms solving differential equations are used in analytical computer codes for modeling, which is the prediction of performance and control of renewable energy systems. To create precise forecasts, this method needs a lot of processing power and time. Instead of requiring intricate rules and mathematical procedures, AI systems can learn important informational patterns. Better, faster, and more useful predictions could be made using AI than with any current method [10].

To conclude, O&M expenses are key to the economic success of the renewable energy sector and are a major factor in crucial metrics like LCOE. It is essential to find problems early on to reduce O&M costs. Since catastrophic equipment damage can be avoided and time-consuming repair schedules can be completed in advance, it is crucial to anticipate a breakdown. AI, IoT, and robotics are examples of novel technologies that can be used to do proactive PV panel maintenance, which will improve energy production efficiency and minimize energy costs.

# 3 Utilising Deep Learning Models for Fault Detection and Diagnosis

## *3.1 Introduction and Motivation*

Recent years have seen a rapid increase in the use of PV electricity. Since 2010, the cumulative annual growth rate of the PV market and the global expansion of PV capacity have increased consistently at average rates of 20% and 12% year over year (YoY), respectively [12]. Most importantly, the increasing trend of PV capacity continues despite the COVID-19 pandemic in 2020 and 2021 [13]. The exponential expansion of PV systems suggests that the world is shifting toward renewable energy sources. However, this quick expansion places significant pressure on the solar energy industry's manufacturing sector to satisfy such high demand, resulting in several challenges related to system quality, particularly its most critical component: the PV module.

The current method for assessing the quality of PV modules mostly comprises of failure detection and diagnosis (FDD) during the production phase, which is difficult due to a variety of issues. The most important aspect is that these flaws cannot be seen with the unaided eye. As a result, sophisticated apparatus and trained staff are necessary to make this procedure possible. Even with the availability of competent staff, errors made during the procedure can be significant. Due to the aforementioned high demand affecting the industrial sector, experienced employees are usually committed to long working hours. Thus, they are prone to blunders because of exhaustion and weariness.

FDD processes have long been critical in a wide range of sectors, from aircraft [14] to automobiles [15], medical equipment [16] and semiconductor devices [17]. The fundamental goal of the FDD process is to discover and diagnose errors as well as their related root causes early enough to allow fixes before further harm to the system or loss of service happens [18]. Since PV systems serve as power generators, failures in any component can adversely damage efficiency, energy production, security, and dependability if not detected and corrected quickly [19]. As a result, problems must be detected correctly during the production phase to maintain optimal efficiency and energy yield while minimizing cost of maintenance and corrective operations.

FDD systems are classified into two types: model-based and data-driven techniques. Model-based systems incorporate domain knowledge into the system to develop a model that compares measured values of critical system parameters to reference values—commonly known as golden samples—to derive a forecast [20]. Data-driven models, on the other hand, have been constructed based on observations of input and output data [21, 22]. Thanks to the availability of massive data, substantial processing power, and the breakthrough of deep learning, the employment of data-driven system has becoming increasingly appealing [23].

Recent breakthroughs in machine learning approaches for image classification and pattern recognition have shown that they are completely practical for visual fault detection tasks. Few studies, however, have shown conclusive success in integrating deep learning models into the FDD process for manufacturing silicon PV modules using small datasets. As a result, the goal of this study is to propose a strategy to apply deep learning for the FDD of visual flaws on silicon PV modules intending to simplify and automate current reliability testing methods throughout the manufacturing process. The study consists of the following tasks to accomplish the objective mentioned above:

- Provide a comprehensive exploratory data analysis using a given dataset.
- Experiment with several techniques based on both supervised and unsupervised learnings to detect and diagnose visual faults and defects presented in a module using the aforementioned dataset.
- Experiment with several nuances relating to practical realizations of deep learning models.

## *3.2 Related Works*

**Exploratory Data Analysis**

Exploratory data analysis is a crucial procedure that entails performing early investigations on data to find patterns, identify anomalies, test hypotheses, and validate assumptions with the aid of summary statistics and graphical representations [24]. Despite its significant role, there is seemingly a scarcity of research on how exploratory data analysis is applied in image classification as a pre-screening step. The most recent study that involves this particular subject is [25], where a comprehensive exploratory data analysis approach consisting of two primary processes for image classification is introduced. First, statistical features (e.g., mean, median, standard deviation, etc. of pixels) of the images and the regions of interest are calculated, respectively. Then the "textual" features associated with the regions of interest are extracted and described in three principal forms: statistical (calculated by the Gray Level Co-occurrence Matrix), structural, and spectral.

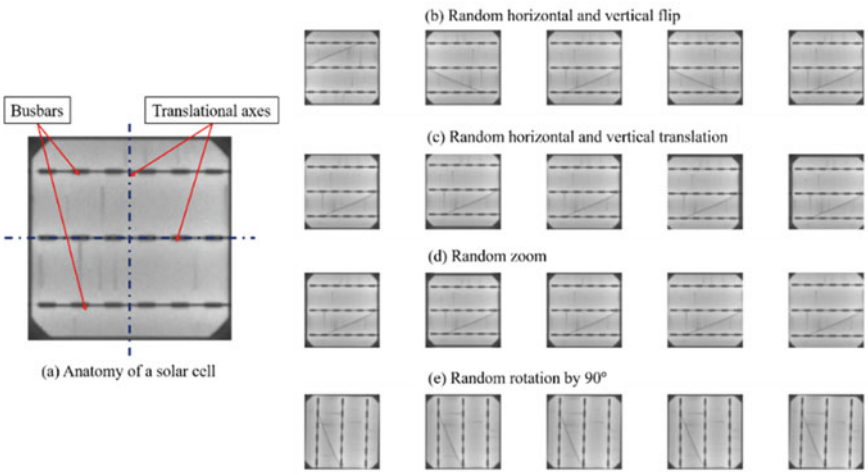



**Fig. 1** Effects of the proposed data augmentation on the dataset. **a** Anatomy of a solar wafer; **b** Results of random flips along the translation horizontal and vertical axes; **c** Results of random horizontal and vertical shifts; **d** Results of random zoom along the translation axes; **e** Results of random rotation by 90°

## Architecture Selection

To achieve the best possible results on the given dataset, the means of transfer learning and the "caviar" strategy are conducted. The "caviar" strategy refers to the practice of developing and training multiple models and selecting the model having the best learning curve. Following this strategy, a total of five models are proposed, four of which are supervised learning models and the final one is an unsupervised learning model (Fig. 1).

Consider the supervised learning approach. Currently, there are more than 50 network architectures that deep learning practitioners can select for their intended classification tasks [26]. Consequently, it leads to the 'paradox of choice' where the availability of many options can problematize decision-making. To resolve this issue, the following approach, consisting of two steps for architecture selection, is proposed: First, only the models whose Top-1 accuracy is higher than 75% are considered to narrow down the number of options based on a common network scheme. From each scheme, the model with the highest Top-1 accuracy score will be picked. Using this approach, these four architectures have been chosen as follows:

- VGG19. This architecture is the best representative of the Stacking scheme, where convolution layers are stacked to get a deeper network [27].
- ResNet152v2. This architecture is the best candidate among those from the Residual scheme, where residual blocks in the network are employed to prevent the gradient vanishing problems [28].
- InceptionResNetv2. This architect has the best performance among networks that are built using the repetition of sparsely connected layers [29].

- NasNetLarge. This architecture is the best representative of the Neural Architecture Search scheme [30].

Having selected the suitable architectures, the four models, titled A, B, C, and D, are then implemented. Each model has the same number of fully connected layers (four of them), and the number of units for the first two fully connected layers is the same (4,096 units). The number of units for the third fully connected layer is selected to be equal to the number of kernels employed in the last convolutional layer in each respective model. ReLU is used as the activation function in all fully connected layers except for the final layer, and sigmoid is used as the activation function of the final fully connected layer because the output results are defined as defect probability. To avoid potential overfitting issues, two dropout layers are included, and the dropout rate is 20% for these layers. Figures 2 and 3 present the architecture of the proposed models used for the prediction of defect probability in the electroluminescence images of solar cells.

For the unsupervised learning approach, another model titled Model E is considered. The architecture of the proposed model is selected under the principles of a convolutional autoencoder, which is commonly employed for reconstruction-based

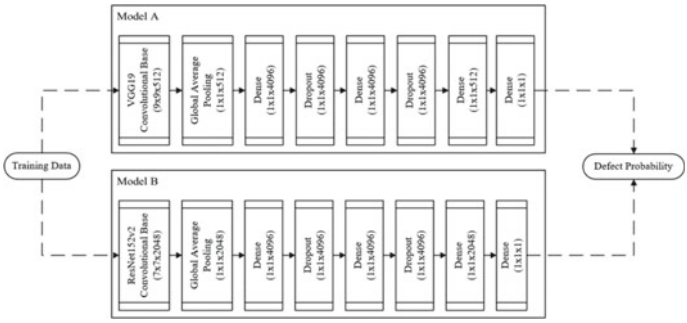



**Fig. 2** Architecture of the proposed classification models (Model A and Model B)


**Fig. 3** Architecture of the proposed classification models (Model C and Model D)

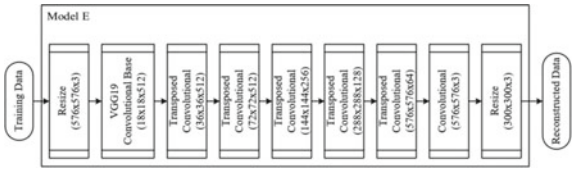



**Fig. 4** Architecture of the proposed reconstruction model (Model E)

anomaly detection. In this case, a VGG19 architecture with some modifications is used for the encoder component: the last three fully connected layers of the VGG19 architecture are stripped away, and only 19 convolutional layers are retained. For the decoder component, five transposed convolutional layers are used with a kernel size of three, and a stride of two. The number of filters employed in these layers is mirrored to those of the final layers in the convolutional blocks of VGG19, and the ELU function is selected as the activation function for these layers. The final layer of the decoder is a convolutional layer with three filters, a kernel size of three, and a linear activation function. Figure 4 presents the architecture of the proposed reconstruction model.

## 4 Results and Discussions

### Exploratory Data Analysis

The distributions of statistical parameters for samples grouped by both cell types (monocrystalline vs. polycrystalline) and defect probabilities (0%: functional; 33 and 67%: marginally defective; 100%: defective) are visualized in Fig. 5. It can be observed from Fig. 5 that, the statistical parameters derived from defective samples (defective probability $\geq$33%) are typically lower compared to those of functional samples. In terms of mean, median, and mode of pixels, it is postulated that there is no statistical difference between the functional and marginally defective groups per cell type. Such validation test for the aforementioned claim, however, is unfeasible since there is a dis- parity between the sample size of these groups (1,508 functional images vs. 401 marginally defective images). Assuming that there is no statistical difference between these parameters, the proposed classification models are expected to have the less discriminative capability for the functional and marginally defective groups.

Figure 6 illustrates the average images derived from functional, marginally defective, and defective samples grouped by cell types. At first glance, there is no visual difference between these groups. The contrast images in Fig. 7, however, demonstrate otherwise.

Figure 7 illustrates the dissimilarity between functional, marginally defective, and defective samples grouped by cell types. For monocrystalline samples, regions associated with the busbars display the most deviation. Thus, it can be theorized that defects occurring in monocrystalline solar cells are commonly materialized

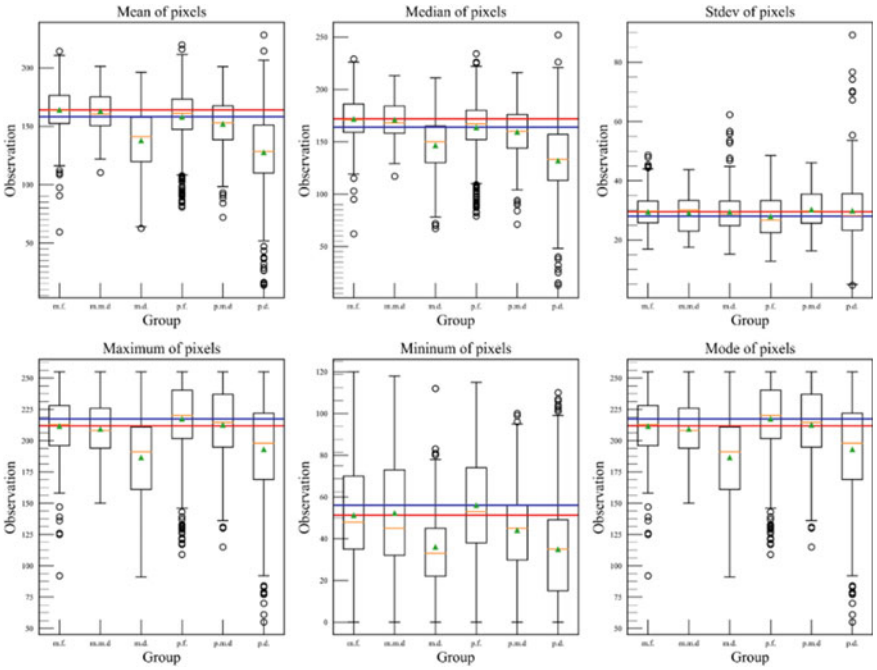



**Fig. 5** Distributions of statistical parameters for samples grouped by both cell types and defect probability. Labels **m.f.**, **m.m.d.**, **m.d.**, **p.f.**, **p.m.d.**, **p.d.** are abbreviations for mono-functional, mono-marginally-defective, mono-defective, poly-functional, poly-marginally-defective, and poly-defective, respectively. The mean value of computed statistical parameters for mono-functional (red) and poly-functional (blue) are used as baselines

around the bus bars. On the other hand, most deviations between good and bad polycrystalline samples are located on both the left side and the middle of the cell. Hence, these regions can be postulated to be plagued with damages, deformities, and faults. Upon further verification [31], these conjectures proved to be valid for the following reasons:

- The cell's busbars usually experience disconnection failure mode since they act as a means for cell interconnection. To form an interconnection between two or more solar cells, a long metal conductor is soldered directly onto the busbars to form a bridge. Therefore, the reliability of the interconnection solely relies on the soldering quality.
- Micro-cracks (due to mechanical damage by various factors) and cell discoloration (mostly due to long-time usage) are commonly found on both sides and the middle area of the cell.

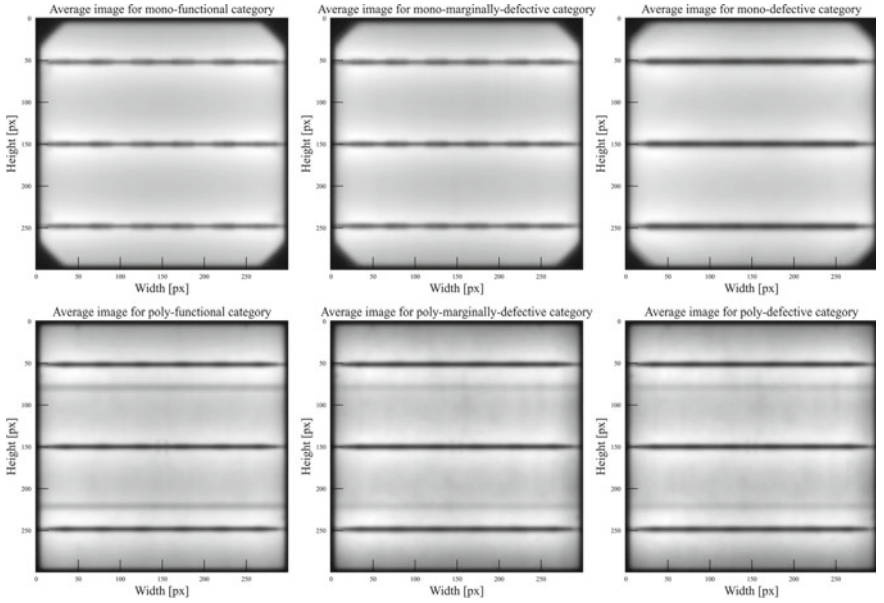



**Fig. 6** Computed average images between the functional, marginally defective, and defective samples

## Model Performance

Figure 8 presents the accuracy performance of the training subset and validation subset in detail against the number of epochs during the training process for all proposed classification models. According to Fig. 8, the accuracy for each respective model increases rapidly along with the increase in the number of epochs, and finally, the training process converges within around 100 epochs in both phases. Except for Model A, the proposed models achieve outstanding training accuracy results which are greater than 85%. However, all models experience a serious overfitting problem since there is a significant difference in mean classification accuracy between the train and validation subsets ($\geq$10%). Such problem is likely caused by the following primary reasons:

- The size of the training set is insufficient. As mentioned earlier, the ELPV dataset used in this study contains only 2,624 samples meaning there are only 1,895 samples for training given the train-test split is 85:15. Even with the proposed data augmentation scheme (random flip, random rotation, random shifts, and random zoom), the expected size of the training set is $1,895 \times 5 = 9,475$ samples, still smaller than the typical size of training sets employed in deep learning studies. Moreover, the results from the above PCA and t-SNE analyses indicate that more data are needed to increase models' discriminative capabilities.

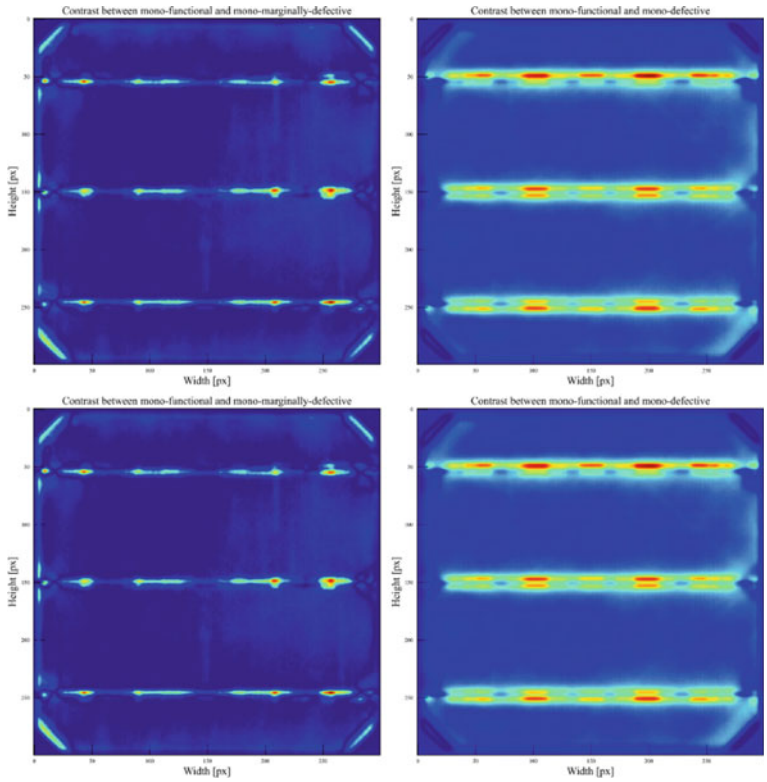



**Fig. 7** Computed contrast images between the functional, marginally defective, and defective samples. Regions that are most deviated are colored red, while most similar regions are colored blue

- Model complexity. Since the proposed models contain three fully connected layers and each layer has a high number of units (≥1,000 units), the usage of regularizers including Lasso and Ridge as well as a higher dropout rate (e.g., 50%) are necessary to ameliorate the overfitting issue.

Figure 9 presents the accuracy, precision, recall, and F1-score results on the validation subset and one test set for all classification models. Figure 9 also provides the results of the ROC and AUC analysis for all models on the test set. The validation scores are extracted from an epoch containing the highest validation accuracy after the two-phase training process. It can be observed from Fig. 9 that, Model B by far has the best overall performance since it possesses the highest validation accuracy (76.71%) and validation F1-score (65.38%). The second best-performed model is Model A, whose validation accuracy and validation F1-score are 74.63% and 62.01%, respectively. Interestingly, Model C and Model D, which are adopted from two models possessing some of the highest Top-1 accuracy scores, are outperformed by Model A and Model B in terms of validation accuracy and F1-score.

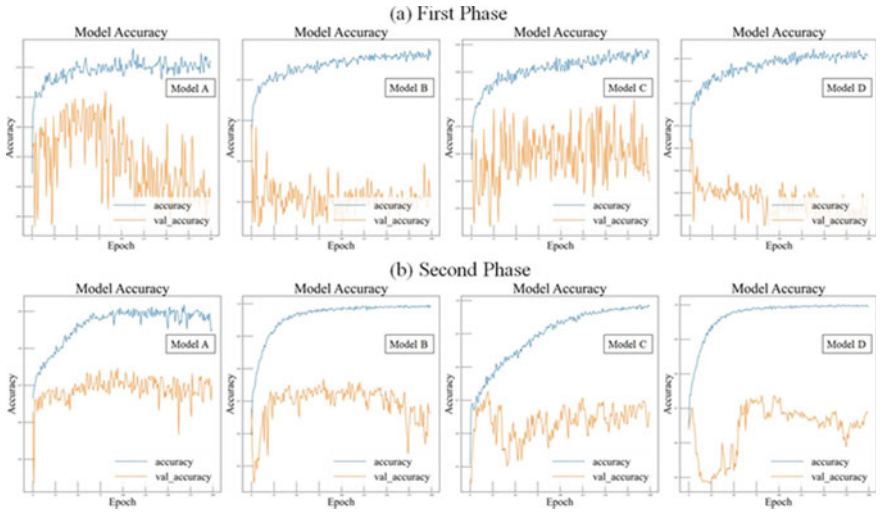
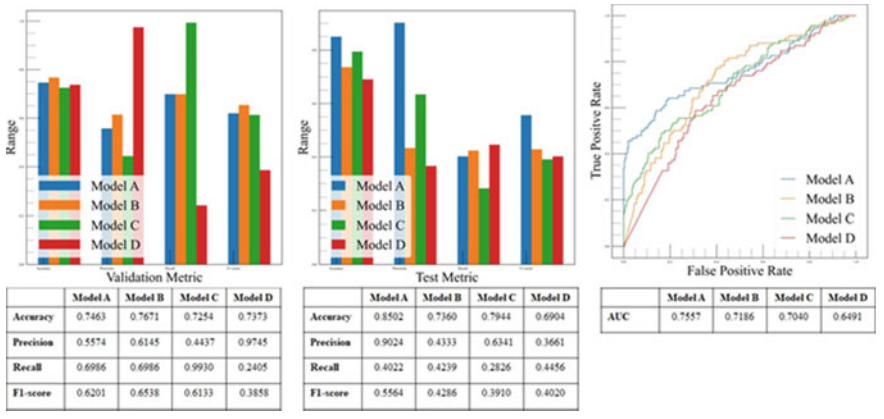



**Fig. 8** Performance assessment of proposed classification models during the training process (first and second phases)

Nevertheless, Model D has an exceedingly high precision rate (97.45%), and Model C has a near-perfect recall rate (99.30%). Hence, Model D is exemplary in identifying defects with high accuracy since the number of false positive cases is zero as the precision rate approaches 100%. Meanwhile, a near-perfect recall rate at Model C means that it can potentially detect most of the occurring defect cases.

When assessing the performance on the test subset, clearly Model A by far has the best performance since it has the highest test accuracy (85.02%), an outstanding test precision (90.24%), and the highest test F1-score (55.64%) among the proposed




| | Model A | Model B | Model C | Model D |
|---|---|---|---|---|
| Accuracy | 0.7463 | 0.7671 | 0.7254 | 0.7373 |
| Precision | 0.5574 | 0.6145 | 0.4437 | 0.9745 |
| Recall | 0.6986 | 0.6986 | 0.9930 | 0.2405 |
| F1-score | 0.6201 | 0.6538 | 0.6133 | 0.3858 |

| | Model A | Model B | Model C | Model D |
|---|---|---|---|---|
| Accuracy | 0.8502 | 0.7360 | 0.7944 | 0.6904 |
| Precision | 0.9024 | 0.4333 | 0.6341 | 0.3661 |
| Recall | 0.4022 | 0.4239 | 0.2826 | 0.4456 |
| F1-score | 0.5564 | 0.4286 | 0.3910 | 0.4020 |

| | Model A | Model B | Model C | Model D |
|---|---|---|---|---|
| AUC | 0.7557 | 0.7186 | 0.7040 | 0.6491 |

**Fig. 9** Performance assessment of proposed classification models on the validation subset and the test set

classification models. The AUC of Model A (75.57%) on the test set also agrees with the above statement: the best-performed model is Model A. The second-best model is Model B—whose test F1- score and AUC are 42.86% and 71.86%, respectively—followed by Model C and Model D.

Based on the assessment results above, the most suitable classification model for the target of this study is Model A since it offers competitive accuracy scores, overkill, and underkill rates. The qualitative results in Fig. 10 may provide clues on why Model A provides the best discriminative capability. It can be observed from Fig. 10 that, Model A does provide the most sensible cues on why it infers a specific defect probability for a given observation: it heavily scrutinizes the side regions (top, down, left, and right sides) to discriminate whether a polycrystalline cell is defective. Such method is similar to the contrast image results highlighted in Fig. 7. For monocrystalline samples, in contrast, Model A 'inspects' the entire cell area to infer a defect probability.

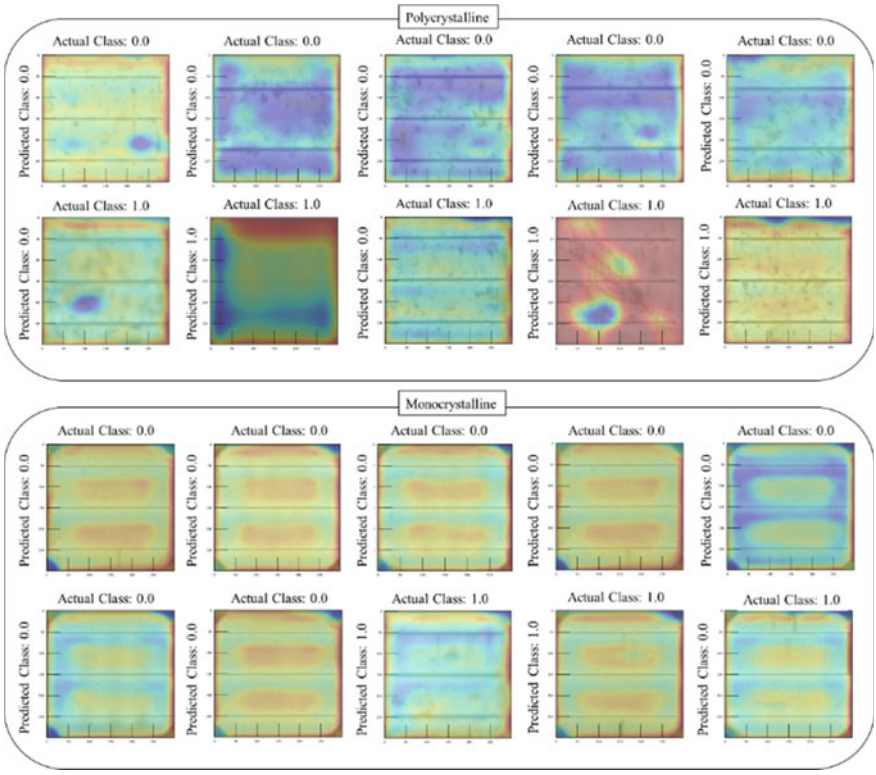



**Fig. 10** Selected qualitative results of Model A on the test subset. Red regions are areas where the model heavily uses to infer a specific probability

## 5 Conclusions

According to the assessment results, Model A has the best performance among the proposed classification models given the above-defined hyperparameters (learning rates, optimizers, number of epochs, etc.) and two-phase training scheme. This raises a question on how optimal hyperparameters can be searched for to yield the best model out of the proposed Model A. Besides, assuming that different versions of Model A with different sets of hyperparameters are initialized, there is also a consideration of how these models can be gauged and compared to select the best one.

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# The Impact of Online Learning Facilities and Activities on the Effectiveness of Online Learning for Secondary Education: The Case of Vietnam


**Thi Yen Tran, Tra My Nguyen, and Ngoc Bich Do**

**Abstract** This study aims to investigate the effectiveness of online learning in light of the recent COVID-19 pandemic and consequent nationwide lockdowns in Vietnam. The focus of this study is on learning facilities and learning activities in secondary education. Secondary data as collected by Bui et al. [1] is utilized. Data collection was conducted through an online survey administered between September and December 2021 to 5,327 secondary school students from five provinces in Vietnam. The authors analyzed the data using Multiple Regression and Exploratory Factor Analysis via SPSS. The results of the data analysis indicate that learning activities and teaching activities have the greatest influence on the effectiveness of online education, in that order of importance. The authors conclude that to enhance the effectiveness of online learning, the most important factors are teaching and learning activities where interaction plays a key role. Online facilities such as tools and platforms have a positive impact on the effectiveness of online learning, but to a much lesser extent.

**Keywords** Online learning · Effectiveness · Vietnam · Secondary education

## 1 Introduction

### *1.1 Research Background*

Online learning is popular due to its benefits and uses. As learning spaces, physical classrooms are losing their monopoly. Numerous researchers and educators are interested in online learning to improve student learning outcomes and combat resource

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reductions. Researchers and educators must compare online learning to traditional face-to-face learning and evaluate the factors influencing the effectiveness of online learning [2]. Its effectiveness in educating students, use as professional development, cost-effectiveness in combating the rising cost of secondary education, and ability to provide a high-quality education to anyone with a broadband connection are of vital importance [3–6]. Khan Academy, Udacity, edX, and Coursera are built on this premise, and many respected scholars and entrepreneurs have high hopes for online learning, especially massive open online courses [7, 8]. The focus of this paper is the effectiveness of online learning compared to traditional learning in secondary education in Vietnam, with a particular focus on online learning activities and facilities.

### *1.2 Research Objective*

COVID-19 resulted in the sudden transition from traditional to online education on a global scale. The purpose of this study is to examine the effectiveness of online education in Vietnam by analyzing the impact of online learning facilities and activities. The research question guiding this study is: how effective are online learning facilities and online learning activities as perceived by secondary school students in Vietnam?

### *1.3 Vietnamese Context*

The first COVID-19 epidemic in Vietnam occurred in late January 2020. The government took a very firm stance and closed down all educational institutions. Consequently, schools and universities were required to quickly shift their teaching to an online format [9]. This was not an easy transition for teachers and students because, for many of them, this was their first exposure to online learning. A significantly high number of students in Vietnam was forced to study online as a result of the epidemic. A survey conducted in Vietnam revealed that only one-third of the students had had any experience with online learning prior to the outbreak of COVID-19 [10]. Zoom, Microsoft Teams, and Google Meet were the three primary streaming platforms used for online learning in Vietnam during the outbreak of COVID-19. Online education has been recommended for many years in Vietnam, but institutions, experts, and students have not shown much excitement for it (Vietnam Economic Times 2018). Institutions in Vietnam had little option but to implement online learning programs throughout the epidemic, which has in turn offered an excellent chance for universities to evaluate their ICT infrastructure, the staff training necessary to provide online material, and other factors [11].

## 2 Literature Review

### *2.1 Online Learning in Covid 19 Pandemic*

The pandemic prompted lockdowns in numerous nations. Following the fundamental principle of social distancing issued across the globe, face-to-face interaction and public gatherings, including in the education sector, must be restricted. Consequently, not only the education sector but also other industries must adopt distance learning. Since then, online learning has begun to garner the interest of scholars who are conducting research on a variety of topics, such as how to engage students in virtual platforms [12], how to integrate student perception [13], and student satisfaction management [14].

Despite benefits such as flexibility, time savings [15], and cost savings from online learning, both educators and students must overcome a vast number of obstacles. According to the findings of Barrot et al. [16], the current challenges can be divided into three major categories: self-challenges, such as self-isolation, depression, or self-regulation; technology issues, such as technical literacy or connectivity; and the availability of learning materials. Those challenges might have a negative impact on learning outcomes and effectiveness.

When it comes to learning effectiveness, it is a significant aspect for both educators and learners whether they participate in an online or offline mode [15] because it will determine the course quality and outcomes. The effectiveness of online learning, particularly amid the Covid-19 pandemic, has been widely studied. In investigating the effectiveness of online learning, Baber [14] found that social interaction, despite social distancing, played a key role in ensuring the continued effectiveness of teaching during the pandemic. Razali et al. [17] identified interaction between students and teachers as the key success factor for enhancing online learning effectiveness. This was expanded to stress the equal importance of interaction among students. In the recent study of Alqurashi [18], authors revealed that online learning effectiveness and student satisfaction can be enhanced by a variety of teaching and learning approaches. If those factors maintain the interaction between students and teachers, then there is no significant difference between online and offline learning [19, 20]. Teachers might adopt some learning activities to interact with students and among them. However, as opposed with traditional learning, online learning activities must be performed with the use of digital aids. Therefore, in this study, the authors will examine the two constructs, including online learning facilities and online learning activities, with regards to online learning effectiveness.

### *2.2 Theoretical Background*

The formation of hypotheses in this study is guided by a theoretical framework titled COVID-19 online learning proposed by Tsang et al. [21]. Firstly, other studies

conducted in an online learning environment adopt the Theory of Technology Acceptance model [22] or diffusion model as the fundamental basis. Due to Covid-19 pandemic, students, lecturers, and schools know of no alternative method to perform teaching and studying. Hence, the impact of perceived usefulness and perceived ease of use as determinants of whether students engage in online learning can be neglected. Secondly, as suggested by Tsang et al. [21], during Covid-19 online learning, the learning framework consists of three stages, including input factors such as students, teachers, and universities; process factors, including facilities and collaborative learning methods; and the output factors being satisfaction and performance. Hence, this theoretical pointer was used to form hypotheses to examine the impact of process factors, which are learning facilities and learning activities, on the effectiveness of online learning.

## *2.3 Hypotheses Development*

Learning facilities are defined as all that is necessary to perform the learning process [23]. It consists of two classifications, which are facilities and infrastructure [24]. As such, facilities are the devices and means by which teachers can facilitate the teaching-learning process. Whereas, infrastructure can be the size of schools, class density of learning spaces [25]. Online learning is done remotely. All interaction and activities must be conducted virtually. Therefore, the learning facilities are smart devices such as computers, laptops, or others that can be accessed on the Internet; and the infrastructure might be altered compared to offline mode because students mostly study at home, especially in secondary school. With the support of these devices, teachers and students can communicate in multiple ways with each other, such as teacher-to-students, students-to-teachers and students-to-students. Furthermore, with the proliferation of many applications and teaching tools websites, teachers might use these means to make exams, quizzes, and other learning-games to attract students' attention. Those lead to the student's experience improvement and satisfaction afterwards [26]. Notably, experience and satisfaction are two main determinants of learning effectiveness [27]; thus, the authors predict the direct impact of online learning facilities on online learning effectiveness in the first hypothesis:

**H1: Online learning facilities positively impact on effectiveness of online learning.**

Learning activities have long been researched because they contribute to learning outcomes [28]. In electronic learning, learning activities are performed remotely as game- based learning [29], case-study-lead learning, audio or video learning, for instance. Notably, with children, their attention journey was shorter than adults'. Their attention can be extended if teachers can fulfill some conditions of attention, such as curiosity. Curiosity has developed as human nature, which can be facilitated by classroom activities. In virtual learning, teachers are able to use diverse new techniques such as teaching with cartoon motions or game-based learning. Those

activities might enhance students' enjoyment and lead to engagement as a consequence [30]. Therefore, the authors would like to examine the impact of online learning activities on learning effectiveness in the second hypothesis:

**H2: Online learning activities positively impact on effectiveness of online learning.**

## 3 Methodology

### *3.1 Research Method*

A quantitative research method was adopted in this study. A secondary Mendeley dataset was utilized whereby a survey was administered to secondary students in Vietnam [1]. The questionnaire was divided into four sections: background information, online learning facilities, online learning activities, and the effectiveness of online learning. A total of 12 questions were included in the survey and distributed to Vietnamese students in grades 6 through 9. The survey comprised 64 selected-response and Likert-scale items based on Picciano [31] and a literature review of online education during COVID-19. The online survey was conducted between September and December of 2021, using the Google Forms platform. There were a total of 5,327 secondary school students who participated in the survey, including 2,898 females and 2,429 males from rural, urban, and mountainous regions of Vietnam. The majority of the data was collected in Hanoi, Can Tho, Nam Dinh, Dak Lak, and Quang Binh provinces. The process of school selection was based on a snowballing method with the aim of ensuring maximum possible representativeness of collected data. When compared to the data compiled by the General Statistics Office (GSO) of Vietnam [32], this data portrays a fair representation of the secondary schools' students across the Vietnamese rural, urban, and mountainous regions in the selected five provinces. The proportion of rural and mountainous students is approximately 45% according to the [5] and 58% according to this study's collected data (2022). The authors analyzed the data using Multiple Regression and Exploratory Factor Analysis via SPSS.

## 4 Results

### *4.1 Demographic Data*

The study has 2,898 (54.4%) female and 2,429 (45.6%) male participants. Among 5327 secondary students assessed, 29.3% (1563 observations) are from grade 7, followed by 26.2% (1398 observations) from grade 9, 24.3% (1297 observations)

from grade 8, and 20.1% (1069 observations) from grade 6. In terms of school geography, 2,675 students (50.2%) attend rural schools, 2,234 (41.9%) attend urban schools, and 418 (7.8%) attend mountain schools.

## *4.2 Measurement Validity*

Cronbach's Alpha was used to determine the correlation and link between variables; and Exploratory Factor Analysis (EFA) to analyze the measurement validity between variables and investigate the interaction of several variables within each factor (Table 1).

Cronbach's Alpha coefficients for Student's Proficiency in Using Applications or Platforms (SPAP), Student's Barriers (SB), Frequency in using Teacher's Platforms (FTP), Student's Experience (SE), Teacher's Support (TS), and Effectiveness (EF) in terms of online learning are above the 0.6 threshold [33] (Table 2), indicating that these variables are reliable. In contrast, the Cronbach's Alpha coefficients for Student's Devices (SD) and Students' Platforms in online learning (SP) are below the threshold of 0.6, indicating that SD and SP scales are omitted from the study (Table 2). When separating the data into urban and rural/mountainous areas, these figures are still lower than the threshold of 0.6. The Cronbach's Alpha coefficients for SD and SP for urban students are 0.432 and −0.116, the figures for rural and mountainous ones are 0.537 and −1.556 respectively. Therefore, SD and SP factors are invalid to process.

The EFA analysis includes the following six factors: Student's Proficiency in Using Applications or Platforms (SPAP), Student's Barriers to Online Learning (SB), Frequency in using Teacher's Platforms (FTP), Student's Experience in Online Learning (SE), Teacher's Support in Online Learning (TS), and Effectiveness of Online Learning (EF).

**Exploratory Factor Analysis**. The model consists of seven scales with eight observed variables of one dependent factor and 57 observed variables of six independent factors (which includes one additional observed variable of one factor, Student's IT Skill—SIS). The KMO measure must be larger than 0.5 and less than 1 [34], and the coefficient of statistical significance for Bartlett's test of sphericity must be less than 0.05 [35]. Variables will be retained if a loading factor is more than 0.5 and the Cumulative Variance is greater than 50% [36]. The EFA is run separately for independent and dependent variables.

*Factor analysis for independent variables.* Six independent factors with 57 observable variables influence the efficiency of online learning for secondary students. The majority of variables are bigger than 0.5, satisfying the factor loading threshold requirement. One FTP variable in particular (FTP10) has no value, hence it is removed from the analysis. Aside from that, the SIS variable remains distinct with a single factor, meaning it is likewise eliminated. During this analysis, some variables load more than one factor (two factors in particular), and the difference between loading

**Table 1** Descriptive statistics

| Elements | Means | Standard deviations | Elements | Means | Standard deviations |
|---|---|---|---|---|---|
| SD1 | 1.23 | 0.42 | SE1 | 3.87 | 0.939 |
| SD2 | 1.18 | 0.384 | SE2 | 3.86 | 0.931 |
| SD3 | 1.825 | 0.3798 | SE3 | 3.76 | 0.99 |
| SD4 | 1.41 | 0.492 | SE4 | 3.77 | 0.948 |
| SD5 | 1.17 | 0.373 | SE5 | 3.83 | 0.95 |
| SD6 | 1.11 | 0.311 | SE6 | 3.85 | 0.936 |
| SPAP1 | 3.68 | 0.961 | SE7 | 3.88 | 0.918 |
| SPAP2 | 3.29 | 1.06 | SE8 | 3.86 | 0.931 |
| SPAP3 | 3.76 | 1.003 | SE9 | 3.86 | 0.917 |
| SB1 | 2.22 | 1.073 | SE10 | 3.86 | 0.915 |
| SB2 | 1.75 | 1.072 | SE11 | 3.94 | 0.905 |
| SB3 | 1.82 | 0.988 | SE12 | 3.65 | 1.01 |
| SB4 | 1.78 | 1.053 | SE13 | 3.81 | 0.947 |
| SB5 | 1.48 | 0.916 | SE14 | 3.68 | 0.987 |
| SB6 | 1.58 | 0.991 | TS1 | 3.87 | 0.899 |
| SP1 | 0.64 | 0.481 | TS2 | 3.88 | 0.898 |
| SP2 | 0.27 | 0.445 | TS3 | 3.68 | 0.98 |
| SP3 | 0.38 | 0.484 | TS4 | 3.63 | 1.032 |
| SP4 | 0.01 | 0.098 | TS5 | 3.84 | 0.901 |
| SP5 | 0.27 | 0.446 | TS6 | 3.58 | 1.011 |
| FTP1 | 1.81 | 1.193 | TS7 | 3.8 | 0.914 |
| FTP2 | 1.95 | 1.209 | TS8 | 3.82 | 0.92 |
| FTP3 | 1.45 | 0.911 | TS9 | 3.84 | 0.891 |
| FTP4 | 1.89 | 1.187 | TS10 | 3.71 | 0.989 |
| FTP5 | 1.37 | 0.813 | TS11 | 3.82 | 0.93 |
| FTP6 | 1.56 | 0.965 | TS12 | 3.56 | 1.035 |
| FTP7 | 1.56 | 0.976 | EF1 | 3.85 | 0.885 |
| FTP8 | 1.39 | 0.841 | EF2 | 3.83 | 0.866 |
| FTP9 | 1.49 | 0.932 | EF3 | 3.76 | 0.891 |
| FTP10 | 2.39 | 1.334 | EF4 | 3.73 | 0.921 |
| | | | EF5 | 3.71 | 0.893 |
| | | | EF6 | 3.66 | 0.937 |
| | | | EF7 | 3.72 | 0.978 |
| | | | EF8 | 3.61 | 0.949 |

**Table 2** Cronbach's alpha coefficients

| Variables | Scale mean if item deleted | Scale variance if item deleted | Corrected item-total correlation | Cronbach's alpha if item deleted |
|---|---|---|---|---|
| *Student's devices (SD), Cronbach's alpha* = 0.476 | | | | |
| SD1 | 6.693 | 1.07 | 0.373 | 0.35 |
| SD2 | 6.741 | 1.133 | 0.352 | 0.369 |
| SD3 | 6.096 | 1.494 | −0.074 | 0.579 |
| SD4 | 6.509 | 1.087 | 0.234 | 0.441 |
| SD5 | 6.754 | 1.182 | 0.305 | 0.397 |
| SD6 | 6.813 | 1.257 | 0.31 | 0.405 |
| *Student's proficiency in using applications or platforms (SPAP), Cronbach's alpha* = 0.835 | | | | |
| SPAP1 | 7.05 | 3.314 | 0.756 | 0.715 |
| SPAP2 | 7.44 | 3.301 | 0.638 | 0.831 |
| SPAP3 | 6.97 | 3.32 | 0.7 | 0.767 |
| *Student's barriers (SB), Cronbach's alpha* = 0.859 | | | | |
| SB1 | 8.42 | 16.025 | 0.538 | 0.856 |
| SB2 | 8.88 | 14.85 | 0.702 | 0.824 |
| SB3 | 8.81 | 15.614 | 0.667 | 0.832 |
| SB4 | 8.85 | 14.81 | 0.726 | 0.82 |
| SB5 | 9.16 | 16.107 | 0.66 | 0.834 |
| SB6 | 9.05 | 15.994 | 0.609 | 0.842 |
| *Student's platforms (SP), Cronbach's alpha* = −0.554 | | | | |
| SP1 | 0.93 | 0.488 | −0.171 | −0.418[a] |
| SP2 | 1.3 | 0.435 | −0.049 | −0.732[a] |
| SP3 | 1.19 | 0.497 | −0.186 | −0.379[a] |
| SP4 | 1.56 | 0.574 | 0.138 | −0.670[a] |
| SP5 | 1.29 | 0.691 | −0.385 | 0.035 |
| *Frequency in using teacher's platforms (FTP), Cronbach's alpha* = 0.895 | | | | |
| FTP1 | 15.04 | 45.881 | 0.588 | 0.89 |
| FTP2 | 14.91 | 44.984 | 0.639 | 0.886 |
| FTP3 | 15.4 | 46.603 | 0.754 | 0.879 |
| FTP4 | 14.96 | 45.215 | 0.638 | 0.886 |
| FTP5 | 15.48 | 47.367 | 0.784 | 0.879 |
| FTP6 | 15.29 | 45.994 | 0.755 | 0.878 |
| FTP7 | 15.29 | 46.911 | 0.669 | 0.883 |
| FTP8 | 15.47 | 47.14 | 0.776 | 0.879 |

(continued)

**Table 2** (continued)

| Variables | Scale mean if item deleted | Scale variance if item deleted | Corrected item-total correlation | Cronbach's alpha if item deleted |
|---|---|---|---|---|
| FTP9 | 15.36 | 46.208 | 0.768 | 0.878 |
| FTP10 | 14.47 | 49.178 | 0.312 | 0.914 |
| *Student's experience (SE), Cronbach's alpha* = 0.973 | | | | |
| SE1 | 49.61 | 112.231 | 0.833 | 0.971 |
| SE2 | 49.62 | 112.507 | 0.826 | 0.971 |
| SE3 | 49.73 | 112.63 | 0.765 | 0.972 |
| SE4 | 49.72 | 112.044 | 0.834 | 0.971 |
| SE5 | 49.65 | 111.844 | 0.843 | 0.971 |
| SE6 | 49.64 | 112.134 | 0.841 | 0.971 |
| SE7 | 49.6 | 111.962 | 0.869 | 0.971 |
| SE8 | 49.62 | 111.695 | 0.87 | 0.97 |
| SE9 | 49.62 | 111.502 | 0.895 | 0.97 |
| SE10 | 49.62 | 111.555 | 0.894 | 0.97 |
| SE11 | 49.54 | 112.077 | 0.876 | 0.97 |
| SE12 | 49.83 | 112.332 | 0.762 | 0.973 |
| SE13 | 49.67 | 111.618 | 0.858 | 0.971 |
| SE14 | 49.8 | 112.491 | 0.774 | 0.972 |
| *Teacher's support (TS), Cronbach's alpha* = 0.963 | | | | |
| TS1 | 41.16 | 78.728 | 0.811 | 0.96 |
| TS2 | 41.16 | 78.381 | 0.835 | 0.959 |
| TS3 | 41.35 | 77.719 | 0.798 | 0.96 |
| TS4 | 41.4 | 77.887 | 0.742 | 0.962 |
| TS5 | 41.19 | 78.309 | 0.837 | 0.959 |
| TS6 | 41.45 | 77.522 | 0.782 | 0.96 |
| TS7 | 41.23 | 77.688 | 0.865 | 0.958 |
| TS8 | 41.22 | 77.877 | 0.847 | 0.959 |
| TS9 | 41.19 | 77.983 | 0.87 | 0.958 |
| TS10 | 41.32 | 77.312 | 0.815 | 0.959 |
| TS11 | 41.21 | 78.006 | 0.828 | 0.959 |
| TS12 | 41.47 | 78.107 | 0.727 | 0.962 |
| *Effectiveness (EF), Cronbach's alpha* = 0.954 | | | | |
| EF1 | 26.03 | 31.658 | 0.815 | 0.948 |
| EF2 | 26.05 | 31.555 | 0.849 | 0.946 |
| EF3 | 26.12 | 31.195 | 0.861 | 0.945 |
| EF4 | 26.16 | 31.165 | 0.832 | 0.947 |

(continued)

**Table 2** (continued)

| Variables | Scale mean if item deleted | Scale variance if item deleted | Corrected item-total correlation | Cronbach's alpha if item deleted |
|---|---|---|---|---|
| EF5 | 26.17 | 31.255 | 0.852 | 0.946 |
| EF6 | 26.22 | 31.029 | 0.828 | 0.947 |
| EF7 | 26.16 | 30.943 | 0.795 | 0.95 |
| EF8 | 26.27 | 31.269 | 0.79 | 0.95 |

coefficients is less than 0.2; therefore, each factor must be eliminated in succession until there is no poor factor remaining. As a result, there are five independent factors and thirty-five observed variables in the model to evaluate the effectiveness of online learning, following the elimination of negative components. All existing variables exceed the value of 0.5. The KMO sample adequacy measure of 0.962 indicates that the factor analysis is well-suited to the most recent data. Bartlett's test of sphericity with a p-value of 0.0000 fulfills the statistical significance of the model's threshold criteria [35], meaning observed variables are correlated with each other. Cumulative Variance is 67.602% (>50%), indicating that 67.602% of the changes in variables are explained.

*Analysis of factors for the dependent variable.* The KMO measure of sampling adequacy is 0.94, which satisfies the $0.5 \leq \text{KMO} \leq 1$ threshold requirement, indicating that the factor analysis matches the real data perfectly. At $0.000 < 0.05$, the p-value of Bartlett's test of sphericity indicates the correlation between observed variables inside the factor. $75.797 > 50\%$ Cumulative Variance Explained indicates that 75.797% of changes in factors are explained by observable variables. The exploratory factor analysis component matrix reveals that all observed variables had values more than $0.8 > 0.5$, therefore satisfying the threshold criterion.

Overall, the research model and measuring scales based on EFA include five independent elements that influence the effectiveness of online learning for secondary students and one dependent factor that is the effectiveness itself. This is shown in Fig. 1.

## *4.3 Regression Model*

**Significance of Correlation Coefficient**. The average value of component variables is calculated for each factor. After the exploratory factor analysis, Pearson's correlation coefficient test is used to measure linear correlation between dependent variable (EF) and independent variables (SPAP, SB, FTP, SE, TS) with their average values. Table 3 presents the correlation matrix between factors. The dependent variable EF has the Sig coefficient less than 0.05, thus all variables are statistically significant in terms of the correlation between SPAP, SB, FTP, SE and TS. Based on Pearson coefficients, the positive and negative correlation between variables are shown.

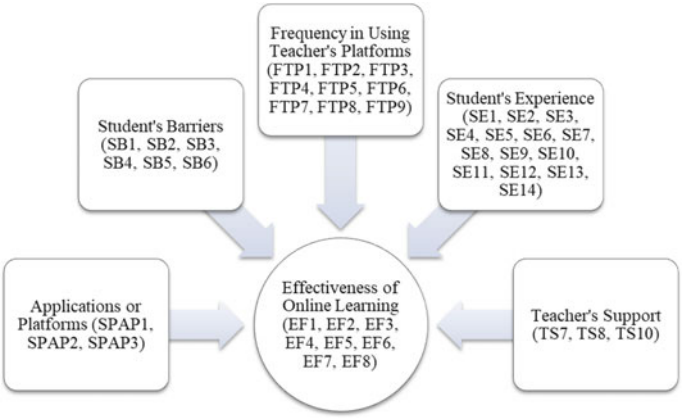


**Fig. 1** Measurement model

**Table 3** Correlations

| | | SPAP | SB | FTP | SE | TS | EF |
|---|---|---|---|---|---|---|---|
| SPAP | Pearson correlation | 1 | $-0.135^{**}$ | $0.167^{**}$ | $0.590^{**}$ | $0.534^{**}$ | $0.547^{**}$ |
| | Sig. (2-tailed) | | 0 | 0 | 0 | 0 | 0 |
| SB | Pearson correlation | $-0.135^{**}$ | 1 | −0.01 | $-0.098^{**}$ | $-0.095^{**}$ | $-0.117^{**}$ |
| | Sig. (2-tailed) | 0 | | 0.642 | 0 | 0 | 0 |
| FTP | Pearson correlation | $0.167^{**}$ | −0.006 | 1 | $0.130^{**}$ | $0.137^{**}$ | $0.123^{**}$ |
| | Sig. (2-tailed) | 0 | 0.642 | | 0 | 0 | 0 |
| SE | Pearson correlation | $0.590^{**}$ | $-0.098^{**}$ | $0.130^{**}$ | 1 | $0.789^{**}$ | $0.788^{**}$ |
| | Sig. (2-tailed) | 0 | 0 | 0 | | 0 | 0 |
| TS | Pearson correlation | $0.534^{**}$ | $-0.095^{**}$ | $0.137^{**}$ | $0.789^{**}$ | 1 | $0.755^{**}$ |
| | Sig. (2-tailed) | 0 | 0 | 0 | 0 | | 0 |
| EF | Pearson correlation | $0.547^{**}$ | $-0.117^{**}$ | $0.123^{**}$ | $0.788^{**}$ | $0.755^{**}$ | 1 |
| | Sig. (2-tailed) | 0 | 0 | 0 | 0 | 0 | |

$^{**}$ Correlation is significant at the 0.01 level (2-tailed)
b Listwise N = 5327

**Estimation of Regression Model**. The independent variables have statistical significance on explaining the dependent variable (Effectiveness of online learning), as shown on the multivariate linear regression model (1) below:

$$\mathrm{EF} = \beta 1 + \beta 1 * \mathrm{SPAP} + \beta 2 * \mathrm{SB} + \beta 3 * \mathrm{FTP} + \beta 4 * \mathrm{SE} + \beta 5 * \mathrm{TS} + \epsilon \quad (1)$$

**Regression Model Discussion**. Table 4 depicts the result of the linear regression model. While SPAP, SB, SE, and TS variables have statistically significant effects on

the EF variable (p-value 0.05), FTP is omitted from the model (p-value >0.05). All VIF coefficients are less than 10, indicating that there is no multicollinearity inside the model. Table 4 demonstrates both positive and negative correlations between independent and dependent variables. The equation of the regression model after removing the FTP variable is as follows:

$$EF = 0.561 + 0.08 * SPAP - -0.027 * SB + 0.458 * SE + 0.314 * TS + \epsilon \quad (2)$$

**Hypothesis Testing**. The hypothesis testing results of the research model are shown in Table 5 after the regression result.

**Regression Model Fit**. The R squared with the value of 0.673 implies that 67.3% of the variability observed in the dependent variable (Effectiveness of online learning) is explained by the regression model with 4 independent variables (Table 6). The Durbin-Watson coefficient is 1.949 which satisfies $1 \leq$ Durbin-Watson $\leq 3$ threshold criteria, thus the autocorrelation does not exist in the regression model.

**Table 4** Coefficients

| Model | Unstandardized coefficients | | Standardized coefficients | t | Sig | Collinearity statistics | |
|---|---|---|---|---|---|---|---|
| | B | Std. Error | Beta | | | Tolerance | VIF |
| (Constant) | 0.561 | 0.038 | | 14.85 | 0 | | |
| SPAP | 0.08 | 0.009 | 0.088 | 8.906 | 0 | 0.627 | 1.596 |
| SB | −0.027 | 0.008 | −0.027 | −3.385 | 0 | 0.981 | 1.02 |
| FTP | 0.002 | 0.008 | 0.002 | 0.193 | 0.85 | 0.969 | 1.032 |
| SE | 0.458 | 0.013 | 0.468 | 34.67 | 0 | 0.337 | 2.963 |
| TS | 0.314 | 0.012 | 0.336 | 26.05 | 0 | 0.369 | 2.708 |

**Table 5** Hypothesis testing

| Hypothesis | | Result |
|---|---|---|
| H1 | Online learning facilities positively impact on effectiveness of online learning | Rejected |
| H2 | Online learning activities positively impact on effectiveness of online learning | Accepted |

**Table 6** Adjusted $R^2$

| R | $R^2$ | Adjusted R square | Std. Error of the estimate | Durbin-Watson |
|---|---|---|---|---|
| 0.821[a] | 0.67 | 0.673 | 0.45522 | 1.949 |

[a] Predictors: (Constant), TS, SB, FTP, SPAP, SE

**Table 7** Variable importance order

| Code | Variable | Standardized beta | Order of importance |
|---|---|---|---|
| SPAP | Student's proficiency in using applications or platforms | 0.088 | 3 |
| SB | Student's barriers to online learning | −0.027 | 4 |
| SE | Student's experience in online learning | 0.468 | 1 |
| TS | Teacher's support in online learning | 0.336 | 2 |

**Variable Importance Order**. The explanation of Table 7 shows how the independent factors affect on the dependent factor (Effectiveness of Online Learning): Student's Experience on online learning has biggest positive impact on the Effectiveness of online learning of secondary students, Teacher's Support has the second biggest positive impact on the Effectiveness of online learning, Student's Proficiency in Using Applications or Platforms has the least positive impact on the Effectiveness of online learning, and only Student's Barriers to online learning has negative impact on the Effectiveness of online learning.

## *4.4 Discussion*

Results show that the effectiveness of online learning in secondary students is positive in correlation with Student's Proficiency in Using Applications or Platforms, Student's Experience in online learning and Teacher's Support in online learning; and negative in correlation with online learning Barriers for students. The order of importance is arranged respectively from Student's Experience in online learning, Teacher's Support in online learning, Student's Proficiency in Using Applications or Platforms to Student's Barriers to online learning. These results are well suited with the general understanding in learning perspective where the interaction between students and teachers is a determinant of effectiveness for both online and offline learning. Studying online also requires students to use applications or platforms as a major tool to serve learning activities. When students meet any trouble during online or face-to-face learning class, the effectiveness of studying is disrupted.

# 5 Conclusion

## 5.1 Summary of Findings

The Exploratory Factor Analysis led to the identification of four distinct factors that, when combined, constituted a valid regression model. According to the conclusions of the data analysis, learning activities have the greatest impact on the success of online education, followed by teaching activities, in this order of importance. The extent to which students are adept with information technology has a marginally beneficial effect on the effectiveness of online learning. Access to information technology is the only remaining factor that negatively affects the effectiveness of online education. Consistent with prior research, this study's findings indicate that the most essential criteria for enhancing the effectiveness of online education are teaching and learning activities that involve substantial interaction. Internet-accessible resources, such as tools and platforms, contribute to the effectiveness of online education, but to a considerably lesser extent.

This conclusion can be extended to a wider context beyond Vietnam. However, this conclusion is particularly meaningful for Vietnam, where a general reality is that most students are not tech-savvy, specifically only one-third of the students surveyed had had any online learning experience prior to the pandemic. For many years, online education has been recommended in Vietnam, but institutions, experts, and students have not been enthusiastic about it (Vietnam Economic Times 2018). Throughout the epidemic, institutions in Vietnam had little choice but to implement online learning to simply keep going, which provided an excellent opportunity for universities to evaluate their ICT infrastructure, staff training required to provide online material, and other factors [11]. This study's findings help practically guide educators in enhancing their design of online learning courses by suggesting that what matters most in online learning is the participants' interaction with each other and with the teacher. This implies that instead of focusing all resources on producing the best-looking and knowledge-filled PowerPoint slides, educators should focus on designing highly interactive activities that aim at delivering that knowledge. This is undoubtedly easier said than done, therefore, any enhancements in the ICT infrastructure as well as training for educators should consider "interaction" their primary pointer in efforts to deliver high-quality and effective online courses for secondary students.

## 5.2 Contribution and Limitations

The main contribution of this study is a shift in mentality when designing online courses for secondary students in Vietnam. The general approach of teachers in Vietnam is currently to produce best-looking and most knowledge-filled PowerPoint slides in hope that both students and parents will be satisfied with such a substitute for

traditional learning. However, this has proven ineffective over the entire course of the pandemic. The shift in teachers' mentality should be towards *interactive* activities to deliver said knowledge. Just as teachers lead in-person activities in class, online learning should be no different, if not more so because the types of activities and how they are organized need to utilize digital tools and platforms, which can be more demanding than in-person activities. While still striving to deliver high-quality lessons which fulfill the learning outcomes approved by accrediting bodies, the mode of their delivery must adapt to the changing circumstances. If not for the COVID-19 pandemic, this move would most likely be further delayed in Vietnam, despite the global digital transformation which has taken place in numerous other industries in Vietnam and not education. If online education is to expand post-COVID-19, teachers should receive continuous training on new online teaching technology and apply these new skills into their lessons regardless of the teaching mode, online or offline, to improve their overall pedagogy.

This study's conclusion can assist local and worldwide researchers, policymakers, and educators in enhancing the quality of online learning, particularly in COVID-19 contexts. The results demonstrate the effectiveness of online learning in secondary education in Vietnam during school closures. The questionnaire for this study is based on the Online Education Framework and Theories and a literature analysis of online education in the context of the COVID-19 pandemic. The questionnaire contains four primary topics. The first component addressed the students' demographic information. The second addressed the online learning conditions of the students, including their learning devices, digital platforms and applications, and technical skills. The third summarized the experiences of students with diverse learning activities, modalities, and assessment systems. The last evaluated students' perceptions of the effectiveness of online learning. The representativeness of the population sample is one of the constraints of this study, as there are differences between students, schools, and school locations that can influence the students' impressions of the survey themes and subthemes. Another constraint is that while online learning's effectiveness is subject to the design and delivery of the courses, the role of parents' level of education and IT literacy as well as that of the siblings can also have an impact on how students absorb the delivered lessons. Due to the limitations of this study, it is recommended that future research replicate this study in different school districts, regions, and demographic areas to represent differences among students, school types, and school locations.

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# Improve Information Security Awareness of Economics and Management Students


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**Abstract** In recent years, while Vietnam's information system has experienced strong development, cybercrime is a massive challenge in all sectors. As rates of usage of internet-connected devices continue to increase, cyber awareness turned to be increasingly urgent. Economics-Management (EM) students who will be the workforce and managers in the future, need to be fully equipped with information security knowledge. However, in current EM universities, very few majors have subjects to equip information security knowledge in their curricula. This leads to a question: "Should the subjects of information security knowledge be included in the curriculum for students majoring in EM". This article will answer this question by focusing on measuring the level of awareness of EM students towards untrained students and trained students about subjects related to information security through a survey on knowledge, self-perception, and practical information security behavior with 465 students in EM majors. The analysis results have shown that the students who received the training had a much better level of information security knowledge, self-perception, and behavior than the untrained students. And training in information security for EM students is more necessary than ever.

**Keywords** Information technology · Information system · Cybersecurity · Economics-management students · Economics · Management · Information security awareness

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## 1 Introduction

Currently, with the trend of integration and globalization, the fields of information technology application are becoming more and more popular, ranging from production and business to education and healthcare. In 2020, the count of smart devices employed in diverse fields exceeded 4.2 billion [1]. Nevertheless, the utilization of these devices has brought forth fresh challenges and significant security threats to humans [2], as malevolent actors can exploit these devices to acquire access to private and confidential information, or employ them to initiate more severe attacks.

In Vietnam, this is a potential market for malware industries in the world. Because Vietnam's internet growth rate is quite fast, the percentage of internet users in recent years has increased very rapidly [3]. As of January 2021, Vietnam's population reached 97.8 million people, with an urban population rate of 37.7%, according to statistics. Among them, approximately 68.17 million people, accounting for 70.3% of the population, are utilizing the Internet through various platforms and applications. On average, they spend 6 h and 47 min per day online, which is considered a relatively substantial amount of time [3]. However, according to Bkav Cybersecurity Group's statistics, there were 70.7 million computer infections in Vietnam in 2021 [4]. The damage inflicted upon Vietnamese users by computer viruses in 2021 will persist at an incredibly high level of 24.4 trillion VND (equivalent to 1.06 billion USD), as indicated by statistics from cybersecurity company Bkav [5].

At present, Vietnam has witnessed robust development in its information system, with numerous Vietnamese companies making substantial strides in developing and implementing information systems to bolster their business success [6]. Additionally, Vietnam has emerged as a sizable market for the development, application, testing, and expansion of diverse information system applications [7]. While the awareness of information security of Vietnamese internet users is still low compared to other countries in the world, most of them are not well equipped with technology and security information security skills [3]. To protect individuals, organizations, businesses, and the economy, all employees need good information security awareness, not just technical experts. EM students will be future employees and managers of the economy, so they must receive information security and cybersecurity training in university to prevent future economic losses. However, most technical students receive training in information security, while few EM students do. The article aims to determine if information security training for EM students is necessary and effective.

Should information security be trained for all students majoring in EM?

What is the difference between students who have been trained in information security and students who are not trained in information security?

The main contributions of this paper are: measuring the awareness of information security for students of EM majors for students who have studied and students are not trained in information security, determining whether the Information security subject is really necessary to be included in the curriculum for students majoring in EM by conducting a survey with a representative sample size of 465 students from the University of Economics and Law, from which conclusions, solutions, and strategies

can be drawn to improve information security awareness for students, helping them to become one of the elite future employees in the eyes of employers. The rest of the paper is organized as follows. In next section, we describe related work on this topic. In Sect. 3, Research methods are thoroughly discussed. In Sect. 4 results of the study are discussed. Finally, we draw the conclusion from our study.

## 2 Related Work

One of the reasons leading to information insecurity in businesses and organizations today is the low awareness of information security of each individual. In the world today, there have been many research papers on raising information security awareness for students and proposing solutions to ensure information security, but these studies only focus on one area or on a specific platform. And some research papers have also been done on students, but for EM students, very few articles mention it. This section briefly presents relevant research in cybersecurity awareness and training in the education sector.

Filippidis et al. measure information security awareness aimed at information technology students in Greece. The study investigated the correlation between cognitive levels and behavioral patterns. The results revealed that students possess awareness of information security, but their knowledge and implementation of techniques and tools remain limited and require improvement [8]. Alan Hughes conducted an analysis of factors related to information security attitudes and behavior among students at a university of the arts in the Southeastern United States. Research results show that it is necessary to provide training courses on information security that affect both attitudes and behaviors for higher education students [9]. Another survey was conducted of undergraduate students in the US Pacific Northwest, 498 students participated, and the results indicated that a significant portion of the students were unable to define terms such as malware (55%), successfully Troy (52%), scam (50%), and worm (17%) [10].

Most undergraduate students are not unaware of information security concerns, at the same time are not aware of all the security risks and necessary security practices [11]. Information security has become important to any organization, so organizations using information systems must make information security a top priority. Currently, in Vietnam, there seems to be no research paper related to information security for students of EM, especially when students of EM will be core employees and potential managers in enterprises. Therefore, the research and awareness-raising for students majoring in EM is extremely necessary. Thus, our team conducted research to measure the awareness of students majoring in EM, thereby offering solutions to raise awareness of information security for students in the context of increasing cyber-attacks since the outbreak of the Covid-19 epidemic until now.

# 3 Research Method

## *3.1 Theoretical Basic*

### 3.1.1 Definition of Key Terms

**Cybersecurity**: Cyber security is how individuals and organizations mitigate the risk of cyber-attack through cyber security measures [12].

**Information system**: Information resources are organized in a discrete set for the purpose of collecting, processing, maintaining, using, sharing, disseminating, or disposing of information [13].

**Information security awareness**: An employee's general knowledge about information security and their awareness of their organization's Information Security Policy (ISP) define information security awareness (ISA) [14].

**Economics**: The study of scarcity and its implications for resource utilization, production of goods and services, growth of production and welfare over time, as well as numerous other intricate issues of significant societal concern, is encompassed by economics [15].

**Management**: Management is the process of collaborating with and leveraging the efforts of others to successfully accomplish the organization's objectives, while optimally utilizing scarce resources in an evolving world [16].

### 3.1.2 Impact of Information Security Breaches

Cyber threats have become increasingly sophisticated in recent years, with a 300% increase in cyberattacks since the start of the COVID-19 pandemic [17]. The costs associated with cybercrime have also risen dramatically by over 2,400% [17]. Google research has revealed that Corona-themed files and links have been used in more than 18 million phishing attempts [17]. Furthermore, Cybercrime-related losses are projected to exceed $10.5 trillion by 2025, making it the world's third-largest economy behind the US and China [17].

Vietnam ranks 21st globally in phishing attacks with 673,743 attacks recorded in 2020 [17]. More than half of the attacks target banks and financial institutions, causing nearly 100 billion VND from 4,000 cyberattacks in losses in 2020 [17]. Computer malware damage to Vietnamese users reached VND 24.4 trillion in 2021, twice as much as in 2017 due to the increasing use of computers and smart devices [17].

Many information security breaches are the result of willful or negligent actions by company employees [18] who were college students, and they may have formed bad security habits [18]. Today's students are the future employees in businesses and other organizations who can bring their technology practices into their careers [19].

Several factors can combine to influence student security behaviors. Among these factors are students' knowledge of information security [9], intentions and behavioral habits [20]. Students' perception of their ability to use a certain security mechanism can also be a predictor of students' information security behaviors [20].

### 3.1.3 Practical Information Security Training for Students in Vietnam

In terms of information security awareness training for students, there is still a low level of awareness regarding security expectations and threats. Currently, a few Economics and Management majors in universities have incorporated Information Security as a subject into their curriculum, although the percentage is still relatively low compared to Engineering majors. For instance, at the University of Economics Ho Chi Minh City, only certain majors such as Management Information Systems, E-commerce, and Software Engineering offer subjects related to information security. Conversely, majors in economics and management have few if any subjects in their curriculum that cover information security [17]. Similarly, at the Foreign Trade University in Vietnam, most EM majors lack any subjects that relate to information security [21].

The research team conducted a survey with a representative sample of 465 students from the EM major from all faculty of the University of Economics and Law, in which there are only 3 majors have subjects related to information security, which are Management Information Systems, E-commerce, and Foreign Economic Relations. This number only accounts for 3/17 (17.6%). This number is quite low compared to the current demand with the ongoing covid epidemic and the information security risk at an alarming level.

## *3.2 Research Methods*

Our study researched a representative sample of 465 students from the University of Economics and Law in Vietnam, without conducting a full-scale study due to resource and time constraints. University of Economics and Law is a university that trains and researches in economics, business management, and law in Vietnam in general and in the southern region in particular, outstanding with its strong teaching capacity, are classified in the group of key national universities in Vietnam. Therefore, this sample size can be representative of the Universities of Economics and Management in Vietnam.

The research was conducted through two steps which are preliminary qualitative research and formal quantitative research. In the preliminary qualitative research, methods refer to theories, documents, and related research works to determine the factors affecting students' information security awareness. At the same time, using the personal interview method, interviewing students in the University of Economics and Law for two groups of trained and untrained students. After the results of the

interview, the group synthesized, adjusted, and supplemented the observed variables to complete the questionnaire. The research team used a quantitative method, sending a survey to all Economics-Law students via Edu email to collect data on their self-perception, knowledge, and behavior regarding information security. The collected data will be cleaned, processed, and analyzed using descriptive statistics and Cronbach's Alpha reliability coefficient. However, the team also used composite reliability to better assess the reliability of the scale, as Cronbach's Alpha tends to underestimate internal consistency [22]. In addition, the research team also uses tools such as Power BI to draw graphs to clearly visualize indicators of knowledge, self-perception, and behavior to test research hypotheses.

## 4 Results and Discussion

Out of the total sample size of 465 students surveyed, 41.1% (191 students) have studied information security-related subjects, while 58.9% (274 students) have not. The majority of students who have studied information security-related subjects are from the Faculty of Foreign Economic Relations (65.66%) and Information Systems (30.3%). Among the surveyed students, 172 (37%) regularly access public Wi-Fi, indicating a lack of awareness of its potential dangers. Additionally, 91% of students are uncertain about the safety of their information, 93% have heard of cases of online or SMS money fraud, and 78% have been warned by banks of such fraud. These findings highlight the urgent need for information security training in schools.

### *4.1 Knowledge of Information Security*

The Knowledge category in the survey provides students with multiple-choice questions about information security. There are 3 questions as follows: "Do you know what the difference is between using HTTP and HTTPS?". The second question with True/False answer is "Turning off your smartphone's GPS function will prevent the phone's location from being tracked." and the third question is "A user purchased a laptop that was infected with a virus. The laptop does not contain Antivirus software and is not connected to the network. What is the best way to repair a laptop?" with 4 answer is "A. Connect the laptop to the network and download the antivirus software from the server", "B. Boot the laptop with the antivirus disk", "C. Connect the laptop to the network and download antivirus software from the Internet" and "D. Uncertain". After consultation with experts, these questions were deemed adequate to assess students' knowledge of information security.

The results of the survey show that students who have studied have a significantly higher rate of "Yes" responses to the first question compared to those who have not studied. Specifically, 91.1% of the students who had studied answered yes, while only 16.42% of the uneducated students responded positively. It is important to note

that protecting personal information is fundamental knowledge, yet a considerable number of students remain unaware of this fact, which can pose a significant threat to their safety. Students who have studied make up a large number of responded positively but still 8.9% have not. These students may face distractions and a lack of focus during the learning process, which may be detrimental to their educational outcomes (Figs. 1 and 2).

With the second question, the correct answer to this question is "False" [23], trained students have also shown a higher rate, accounting for 67.54%. While untrained students accounted for 14.96%. This question is more difficult than the previous one. So many unlearned students are still uncertain and don't know what the answer is (Figs. 3 and 4).

For the third question, the correct answer is "B. Boot the laptop with the antivirus disk" [24], students who have studied account for 127 (66.5%) while untrain student account for 11.3% (Figs. 5 and 6).

The findings from the three questions indicate that students who have undergone training in information security possess a certain level of knowledge on the subject. This suggests that the teaching methods employed have been effective in imparting knowledge to the students. However, it is worth noting that despite their training, some students still demonstrate inadequate knowledge in some areas. This may be due to a lack of awareness of the subject's importance or insufficient effort in attending lectures and engaging in additional learning activities. On the other hand, untrained students show a significant lack of knowledge, which makes them susceptible to poor information security practices that can be exploited by cybercriminals for personal gain.

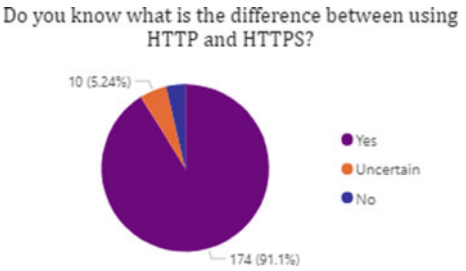


**Fig. 1** The first question for trained student

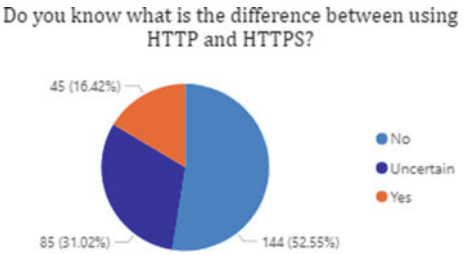


**Fig. 2** The first question for untrained students


**Fig. 3** The second question for trained student

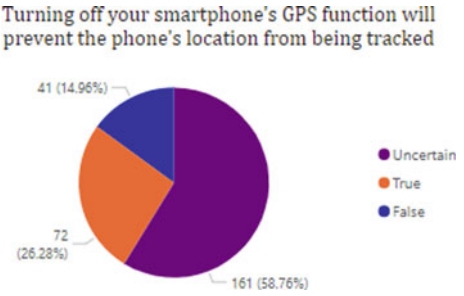


**Fig. 4** The second question for untrained student

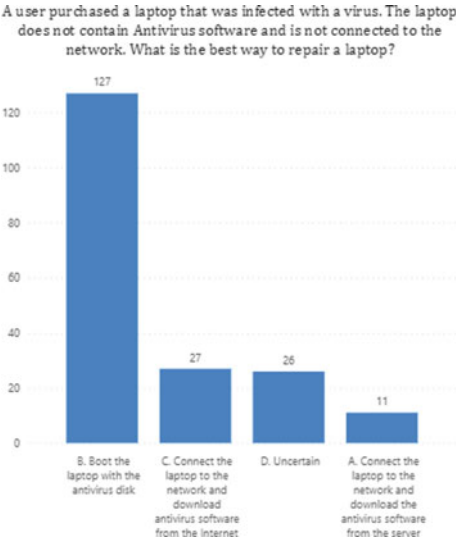


**Fig. 5** The third question for trained student

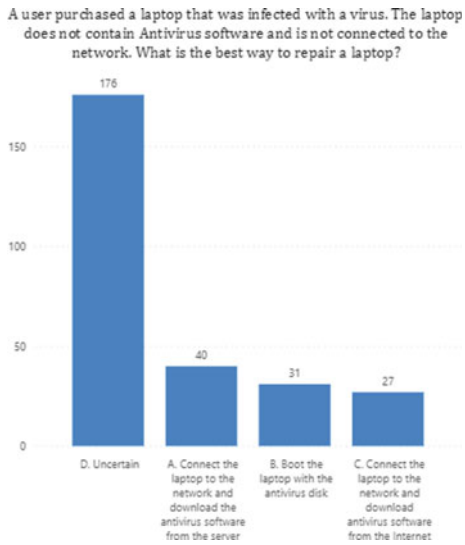


**Fig. 6** The third question for untrained student

## *4.2 Information Security Self-Awareness*

In this study, the authors used a Likert scale with a range of values from 1 to 5 to measure students' opinions on the level of self-perception about information security skills and behaviors (1 = "Strongly disagree", 5 = "Strongly agree") (Table 1).

Cronbach Alpha reliability analysis was performed on 2 data sets representing 2 research groups. An item is considered reliable with Cronbach's alpha score greater than 0.6, with a corrected item-total correlation greater than 0.3. For the untrained group, the test results show that the reliability coefficient of Cronbach's Alpha is $0.928 > 0.6$ and all observed variables have corrected item—total correlation greater than 0.3. With the trained group, Cronbach Alpha gives a result of $0.788 > 0.6$ and all observed variables have corrected item—total correlation greater than 0.3. So with both groups, the scale reached reliable, all observed variables have good explanations for the factor KN. Continuing to perform with composite reliability, the test results show that for the untrained group CR = 0.97 and the trained group CR = 0.95. The results indicates that all factors have composite reliability of at least 0.90, which is higher than the threshold value of 0.70 [25]. It can be concluded that there are no problems with reliability or one-dimensionality in the model.

Uneducated students exhibited a high degree of disagreement and uncertainty, with mean values ranging from 2.49 to 2.82 across the statements. Notably, the statement "I believe I can identify a phishing email or a social engineering attack" had the highest mean value among this group. Nevertheless, the majority of untrained students did not express confidence in their knowledge of information security. Educated students, on the other hand, showed a significant degree of agreement with mean values ranging from 3.41 to 3.89, indicating a higher level of self-awareness regarding their information security skills. This was particularly evident in their

**Table 1** Result of self-perception of information security of untrained students and trained students

| Encode | | Untrained | | Trained |
|---|---|---|---|---|
| KN1 | I believe I can identify a phishing email or a social engineering attack | N | 274 | 191 |
| | | Min | 1 | 2 |
| | | Max | 5 | 5 |
| | | Mean | 2.82 | 3.89 |
| | | Sig | 0.983 | 0.660 |
| KN2 | I believe that I understand anti-virus software, protection software | N | 274 | 191 |
| | | Min | 1 | 2 |
| | | Max | 5 | 5 |
| | | Mean | 2.49 | 3.59 |
| | | Sig | 0.822 | 0.689 |
| KN3 | I believe I know how to protect my personal data and know-how to recover it | N | 274 | 191 |
| | | Min | 1 | 2 |
| | | Max | 5 | 5 |
| | | Mean | 2.62 | 3.65 |
| | | Sig | 0.923 | 0.677 |
| KN4 | I believe that I have enough knowledge and skills to avoid network security incidents | N | 274 | 191 |
| | | Min | 1 | 2 |
| | | Max | 5 | 5 |
| | | Mean | 2.53 | 3.56 |
| | | Sig | 0.894 | 0.692 |
| KN5 | I believe that I know how to respond and handle cybersecurity incidents | N | 274 | 191 |
| | | Min | 1 | 2 |
| | | Max | 5 | 5 |
| | | Mean | 2.55 | 3.41 |
| | | Sig | 0.902 | 0.666 |
| KN6 | I can take appropriate countermeasures and remediation to prevent the impact of ongoing and future attacks | N | 274 | 191 |
| | | Min | 1 | 2 |
| | | Max | 5 | 5 |
| | | Mean | 2.56 | 3.48 |
| | | Sig | 0.872 | 0.709 |

responses to the statement regarding phishing emails and social engineering attacks, which had a significantly higher level of agreement. Overall, the analysis results suggest that students who have received training in information security are more self-aware about the subject than those who have not (Table 2).

For the untrained group, the test results show that the reliability coefficient of Cronbach's Alpha is 0.923 > 0.6 and all observed variables have corrected item—Total Correlation greater than 0.3. With the trained group, Cronbach Alpha gives a

result of 0.789 > 0.6 and all observed variables have corrected item—total correlation greater than 0.3. So, with both groups, the scale reached reliable, all observed variables have good explanations for the factor TT. Continuing to perform with composite reliability, the test results show that for the untrained group CR = 0.98 and the trained group CR = 0.92. The results indicates that all factors have composite reliability of at least 0.90, which is higher than the threshold value of 0.70 [25]. It can be concluded that there are no problems with reliability or unidimensionality in the model.

Uneducated students exhibited a significant degree of disagreement and uncertainty, with mean values ranging from 2.57 to 2.90 across the different aspects of information security behavior. This suggests that untrained students may not have a well-established practice of information security behaviors, particularly in areas such as password management, website legitimacy, and anti-virus software usage. Conversely, educated students showed a higher degree of agreement, with mean values ranging from 3.48 to 3.93, indicating a better application of their knowledge

**Table 2** Actual information security behavior outcomes of untrained students and trained students

| Encode | | Untrained | | Trained |
|---|---|---|---|---|
| TT1 | I regularly update my Windows/ MacOS, antivirus, browser, and software | N | 274 | 191 |
| | | Min | 1 | 2 |
| | | Max | 5 | 5 |
| | | Mean | 2.89 | 3.93 |
| | | Sig | 1.072 | 0.788 |
| TT2 | I regularly change the passwords for my social media and financial accounts | N | 274 | 191 |
| | | Min | 1 | 2 |
| | | Max | 5 | 5 |
| | | Mean | 2.67 | 3.48 |
| | | Sig | 1.053 | 0.864 |
| TT3 | I regularly backup my important data | N | 274 | 191 |
| | | Min | 1 | 2 |
| | | Max | 5 | 5 |
| | | Mean | 2.90 | 3.74 |
| | | Sig | 1.124 | 0.769 |
| TT4 | Before reading an email, I carefully examine the sender's email, carefully and scan the attachments and links in the email | N | 274 | 191 |
| | | Min | 1 | 2 |
| | | Max | 5 | 5 |
| | | Mean | 2.80 | 3.66 |
| | | Sig | 1.154 | 0.835 |
| TT5 | Before installing software from any source, I will check for viruses with an anti-virus software | N | 274 | 191 |
| | | Min | 1 | 2 |
| | | Max | 5 | 5 |

(continued)

**Table 2** (continued)

| Encode | | Untrained | | Trained |
|---|---|---|---|---|
| | | Mean | 2.47 | 3.57 |
| | | Sig | 0.993 | 0.811 |
| TT6 | I usually check the legitimacy of a website before accessing it | N | 274 | 191 |
| | | Min | 1 | 2 |
| | | Max | 5 | 5 |
| | | Mean | 2.34 | 3.54 |
| | | Sig | 1.053 | 0.819 |
| TT7 | The passwords for my personal accounts are complex and contain no personal information | N | 274 | 191 |
| | | Min | 1 | 2 |
| | | Max | 5 | 5 |
| | | Mean | 2.19 | 3.73 |
| | | Sig | 1.097 | 0.870 |
| TT8 | I usually check the legitimacy of a website before accessing it | N | 274 | 191 |
| | | Min | 1 | 2 |
| | | Max | 5 | 5 |
| | | Mean | 2.78 | 3.67 |
| | | Sig | 1.107 | 0.883 |

into information security practice. Specifically, trained students displayed a high level of agreement in regularly updating their Windows/MacOS, anti-virus programs, browsers, and software (mean value of 3.93), as well as regularly backing up important data (mean value of 3.74) and implementing password security measures. Although these values are not exceptionally high, they highlight the effectiveness of Information Security training in enabling trained students to possess a better level of information security knowledge, self-awareness, and behavior than uneducated students.

In the survey results, students who have studied are in two faculties, which are the Faculty of Foreign Economic Relations (65.66%) and Information Systems (30.3%). Although the Faculty of Foreign Economic Relations has just introduced Information security subject in the curriculum, the results show that not only technical students but also economics students are studied effectively.

## *4.3 Discussion*

In light of the Covid-19 pandemic, cyber-attacks have increased in frequency and have caused significant damage to the global economy. Many of these attacks have been a result of employee actions, which may have been influenced by their college

experience. However, students' understanding of cybersecurity and information security is generally low, and training in this area is limited to technical students, with only a few economics students receiving such training. It is crucial to recognize that economics students are the future workforce and managers of the economy, and thus require comprehensive information security training.

A survey has demonstrated that trained economics students possess a higher level of information security knowledge, self-awareness, and practical behavior. Trained students scored an average of 75% in knowledge, compared to untrained students who scored only 14.26%. Trained students also exhibited higher levels of self-awareness and practical behavior. However, the discrepancy between the two groups is not significant, and further studies are necessary to determine the underlying causes and to enhance information security training for economics students.

## 5 Conclusion

Based on the results above, it is evident that information security training for students majoring in EM is essential to improve their security behavior. To raise awareness of information security among students of economics and administration majors, we propose the inclusion of Information security as a compulsory subject in the training program for all majors in the EM section, starting from the first year. This will enable students to be exposed early and form a habit of maintaining confidentiality of their information in the university lecture hall. Also, students can benefit from understanding the importance of information security through better teaching and learning methods. In addition, the school also needs to organize additional extracurricular activities for students to be more exposed to this issue. At the end of the survey, we have suggested some solutions and the students' agreement is quite high. According to the survey, students agreed that they are willing to read security infographics posted on campus (average rate of 3.90), participate in information security seminars (average rate of 3.97), and participate in information security competitions (average rate of 3.73). These additional activities will help students realize the importance of information security in their daily lives.

In general, this study's novelty is based on its exploration of the factors and level of cybersecurity skills among economics students, both trained and untrained. Nonetheless, the main limitation of the study is its respondent type. The sample size is mainly composed of students from the information systems and external economics faculties, which is a convenience sample. To increase the study's reliability, a larger sample size should be used that is not limited to a specific faculty and encompasses a more extensive range of domains.

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# Analysis of the Material, Spiritual Needs of the Elderly and Attractive Market Opportunities in Vietnam


**Nguyen Hoang Sinh and Nguyen Huu Long**

**Abstract** Vietnam's rapidly aging population poses significant challenges to the country's socio-economic development. Despite having relatively strong purchasing power, the elderly in Vietnam are not yet adequately served by social welfare, infrastructure, and products and services targeted to their needs. This chapter explores the material and spiritual needs of the elderly in Vietnam and identifies attractive market opportunities for businesses that can effectively address these unmet needs. Drawing on initial studies on the needs of older adults, we propose solutions to serve these needs in three broad categories: health and medical products/services, specialized food and beverages for the elderly, and social interaction and recreation activities. Our approach is informed by an information systems perspective, and we offer three practical recommendations to meet these unmet needs. Our research provides insights into the unique thinking, lifestyles, and shopping behaviors of today's seniors in Vietnam and underscores the importance of timely and effective adaptation measures to the problem of population aging.

**Keywords** Material and spiritual needs · Elderly · Vietnam

## 1 Introduction

Despite being a country with a desirable "golden population" structure in Southeast Asia, Vietnam also faces the risk of early entering a period of rapid aging. In 2009, the census showed that there were 6.1 million people over the age of 60, accounting for 8.1%. In 2019, the number reached 11.41 million, or 11.86% of the population, an increase of 5 million seniors. The trend is expected to accelerate and by 2035–2038, about 1/5 of Vietnam's population will be elderly [1].

Among many categories of daily products/services in which companies can target the Vietnamese elderly, most of them are left open. Some products and services can be listed as: elderly care product (adult diaper, wheel chair, deaf-aid…), non-medical

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home appliance (washing machine, microwave…), health and medical products/services, residency, transportation for the elder, specialized food and beverage for the elderly, social interaction services and recreation activities (travel, music, sport…), religious/charity activities, elderly apparel, financial services, and legal consulting service.

However, currently there are only two categories with well-established brands, massive distribution, and frequent media communication: nutritional powder/drink (Anlene/Fonterra, Ensure/Abbott, Sure Prevent/Vinamilk—originated as a state-own company and currently the largest dairy company in Vietnam) and adult diaper (Caryn/Unicharm, Abri-Flex/Kimberly Clark).

Regarding residency-related need, the state's nursing homes currently only accept the poor and lonely elderly, and there are only 45 specialized centers nationwide [2]. Private sectors are also under-developed, with only 20 nursing homes operating in 2017. These private nursing home provide catering services, various forms of activities to improve physical and spiritual health, rehabilitation, therapy, and usually have well-trained staff. However, there are two barriers kept these businesses from accelerating: first is the high price, which usually is 10–15 million VND/month [3], much higher than the average monthly income of Vietnamese household. The second and also the main barrier is the tradition of Vietnamese elder to live with and being directly taken care of by their child and grandchildren, and "being sent to the nursing home" perceived as disrespectful.

Alternate option such as family helpers (via direct contact or job centers) also plays a role in the eldercare. Their job can include preparing meals, doing family chores and provide basic medical check-up, and the service than be provide either at home or in a hospital. This kind of care have the advantage that the cost is often lower than that of services provided at nursing homes, and is highly flexible, suitable for the diverse needs of families. However, most of the workers are inadequately trained and operated via a verbal contract. Furthermore, the cost is still high compared to Vietnamese average income.

The present generation of seniors exhibits distinctive thinking, lifestyles, and shopping behaviors that differ from those of past generations. Despite being a sizable demographic group with substantial purchasing power, owing to years of accumulated savings, they face inadequate social welfare and infrastructure, and products and services targeting their needs remain underdeveloped. This study aims to investigate the needs of older individuals, provide initial insights, and suggest ways to address their unmet needs. To this end, we review relevant literature, conduct research and propose recommendations for serving this underserved population.

## 2 Literature Review

### *2.1 Vietnam's Population Transition from 1979—Now: From the Golden Population to Rapidly Aging Population*

The increasing number of older people creates new challenges and opportunities for Vietnam. While in 1979, just under 7% of Vietnam's population was 60 years old or older, conservative estimates by General Statistics Office of Vietnam suggest that this figure will rise to 26% by 2049 [1] (Table 1).

This is the result of the rapid social change that has taken place in Vietnam over the past few years. In the course of 35 years since the economic reform (Đổi Mới, 1986), Vietnam's economic performance has increased tremendously and still keep increasing since the mid-1980s. The country has developed considerably: from one of the poorest in the world to a lower-middle income country. Between 2002 and 2018, GDP per capita increased by 3.4 times [5]. Poverty rates fell sharply from more than 70% of total population to less than 6%, which means more than 45 million people has managed to get out of poverty. Many parts of the Vietnamese have benefited from this economic growth.

Together with the growing prosperity, the living conditions of the Vietnamese have changed significantly. Improvements in nutrition, housing, and health care, immunization (especially the Expanded Program on Immunization) have helped the Vietnamese to reach a higher average age. These changes have drastically affected major population metrics as shown below.

First, infant mortality rate has dropped sharply from 5.5% in 1970 to 1.4% in 2019. Especially in urban areas where infant mortality rate is just 0.82%. As a result, people tend to give birth to fewer children, as total fertility rate is more than 6 children per woman in 1970 but declined to just 2.1 children in 2005 and being stable at this level [6]. Second, since the end of the Cambodian–Vietnamese war, Life expectancy also significantly improves thanks to better nutrition, healthcare, and the lack of military conflict. While average life expectancy is just 65.2 years in 1989 but reached 73.6 years in 2019. According to United Nations (2019), the life expectancy of Vietnam in the period 2015–2020 is far behind Singapore, slightly

**Table 1** The Vietnamese population: rapid growth of the "oldest old" (%)

| Age | 1979 | 1989 | 1999 | 2009 | 2019 | 2029 | 2039 | 2049 |
|---|---|---|---|---|---|---|---|---|
| 60–64 | 2.28 | 2.40 | 2.31 | 2.26 | 4.29 | 5.28 | 5.80 | 7.04 |
| 65–69 | 1.90 | 1.90 | 2.20 | 1.81 | 2.78 | 4.56 | 5.21 | 6.14 |
| 70–74 | 1.34 | 1.40 | 1.58 | 1.65 | 1.67 | 3.36 | 4.30 | 4.89 |
| 75–79 | 0.90 | 0.80 | 1.09 | 1.40 | 1.16 | 1.91 | 3.28 | 3.87 |
| 80+ | 0.54 | 0.70 | 0.93 | 1.47 | 1.48 | 1.55 | 2.78 | 4.16 |
| Total | 6.96 | 7.20 | 8.11 | 8.69 | 11.78 | 16.66 | 21.37 | 26.10 |

*Source* [1, 4]

lower than Thailand, Malaysia and Brunei, but still higher than all other countries in Southeast Asia [4].

As a result, the family structure has changed. Many families today have far fewer children. Not only the number of older people will keep growing, but there are also fewer and fewer young people to provide for them. This change can be illustrated by comparing population pyramids from 1979 to 2029 estimation as shown below.

The age pyramid of the population in 1979 is typical of a population group with high fertility and mortality rates, in which the base is very wide, and the width decreases rapidly in older age groups. After a decade, by 1989, the population pyramid had a large body and a slightly narrower bottom. Despite the decrease in the total fertility rate, the number of people entering childbearing age increased significantly, therefore the number of births increased, and the number of children aged 0–4 was higher than the group of 5–9 years old. The population pyramid in 1999 reflects a demographic transition with rapid declines in both fertility and mortality. The base of the pyramid has shrunk considerably. The body of the pyramid slowly narrows due to mortality rates fell sharply as well as life expectancy increased.

In 2009, the age pyramid corresponds to a post-demographic transition period with low fertility and low mortality and the first signs of population aging. Fertility had fallen drastically, narrowing the bottom three groups. The mortality rate has also decreased, and the body of the pyramid is narrowing towards the base. In 2019, when the large population group born in the period 1985–1994 entered the main reproductive age, the bottom of the population pyramid widened slightly in the last two groups. The body of the pyramid is narrowing more than in 2009. The population pyramid projected in 2029 clearly reflects the situation of an aging population with a narrow body and bottom, when the number of elderly people exceeds 12% of the total population [7].

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a narrow body and bottom, when the number of elderly people exceeds 12% of the total population.

## 2.2 Consequences and Issues: Deteriorating Health and Thin Social Safety Net

As the old Vietnamese saying, "The young lacks wisdom, the old lacks health" ("Khôn đâu tới trẻ, khỏe đâu tới già"), health among the elderly has always been a focused topic in Vietnam society as well as government policy, however the current pension, healthcare facility and other social safety net are still thin compared to other countries with aging population.

**Deteriorating health**: According to a study of the National Geriatric Hospital in 2015, on average, an old person aged 80 or over suffered from 6.9 diseases, 28% of the elderly needed help with activities of daily living (personal hygiene, brushing teeth…), and 90% needed assistance in other activities (buying and selling, cooking, cleaning the house, washing clothes…) [8]. The average number of years living with diseases in Vietnam is also relatively high in comparison with other countries, approximately 11 years in female and 8 years in male [9].

The four main non-communicable diseases (NCDs)—cardiovascular diseases, diabetes, cancer, and chronic respiratory diseases—are the leading causes of mortality. It was estimated that NCDs accounted for about 79% of all deaths in Vietnam by 2019 [10]. Mortality among the older population can mainly be traced back to NCDs which account for an 86–88% of deaths [3]. The most common diseases are listed as below [11]: hypertension, diabetes, chronic obstructive pulmonary disease, and asthma.

**Psychology change**: With the sudden lifestyle changes from being an active member of the workforce to the passive life of retirement, the psychology of the elderly also suffers a drastic change. Major changes are listed by Vietnam Ministry of Health as below [12].

First, the elderly people are afraid of feeling alone, abandoned, and forgotten. The difference in lifestyle and way of thinking between generations in the family often gives the elderly people a feeling of abandonment since their child and grandchildren spend most of their time pursuing career or study or live far away from them. In some cases, the elderly people becoming more silent as if they don't want to talk, but there are also people who become talkative and talk constantly alone, sometimes making loved ones feel uncomfortable, but that's when they need to share and be cared for the most, as they become afraid of the feeling of being alone, dying in the estrangement of their loved ones.

Second, the elderly people often feel helpless. This is the most common condition in the elderly, especially those who are lonely. They often find themselves helpless,

depressed, tired, tormenting themselves. As a result, elderly people with these signs are often prone to depression, temporary memory loss, lack of clarity.

Third, the elderly people's feeling is sensitive and vulnerable. As their health declines, they walk slowly, barely able to work, and their point of view in life is vastly different from the next generation, so even a slightest attitude or a careless word is considered hurtful and can damage the elderly's self-esteem, cause negative behaviors such as self-loathing, skipping meals, not wanting to talk, or even running away from home.

Fourth, the elderly people often feel nostalgic about the past. The elderly people live with nostalgia and the regrets of their youth. Because of that, they talk about the past more than the present and take pride in their past life experiences. They want to go back to the past to live with old memories of a narrow world. Because of this, young people often think that our grandparents are old-fashioned and outdated. This often widens the gap between the two generations.

Fifth, the elderly people always want to feel being cared of. One of the most important aspects in living a healthy daily life of old age is being frequently taken care of by their loved ones, both materially and mentally. Seemingly simple, but in old age it becomes extremely important. The elderly wants and desires to be cared for, asked questions every day, and their children and grandchildren meet their basic needs.

Last, the elderly people are afraid of facing death. For many people, getting older means that death is near. Although knowing that it is the law of nature and no one is spared, but even so, the elderly people are still afraid of facing death. There are also some cases where the elderly discusses the expected funeral for themselves, write wills for their children and grandchildren… but there are also those who do not accept it, avoid it and are afraid of thinking about death.

**Health care service and health insurance**: Only the disabled elderly and those over 80 years old are given free health insurance. The national Social Health Insurance (SHI) targets were set to obtain over 90% coverage by 2020 and 95% coverage by 2025. Since then, health insurance development has become more intensified, covering 86.9% of the population in 2018 [13]. However, under the Health Insurance Law, some health checkup services for early detection of non-symptomatic NCDs are not covered by health insurance. Thus, chronic diseases normally are detected at an older age and a late stage of progression (Table 2).

The Community Health Centers (CHCs)—which cover all communes—traditionally focused on maternal and child health and are less equipped, lack of well-trained personnel, inadequate sanitary conditions and have largely not been given

**Table 2** Social health insurance coverage in older people group (%)

| Year | 2010 | 2012 | 2014 |
|---|---|---|---|
| Male | 62.2 | 65.4 | 71.7 |
| Female | 59.0 | 64.0 | 72.6 |

*Source* Vietnam Living Standard Surveys [quoted in HelpAge International 11]

the mandate, according to policy and regulations of the health sector, to address the growing profile of NCD. Furthermore, most CHCs did not provide preventive services for early detection and management of long-term treatment of patients with NCDs (especially hypertension and diabetes).

However, the current hospital system at district level was quite well-perceived by the elderly (Table 3). This may happen thanks to the policy of prioritizing the elderly and the culture of respecting the elderly in Vietnam as well as better facility compared to CHCs.

**Pension and other benefits**: Regarding the types of pensions, currently, Vietnam has three types as follows: pensions from the State budget, pensions from the Vietnam Social Insurance Fund; and pensions in the form of social pensions coming from the state budget.

Pension from the State budget: This is the pension of the elderly group who retired before 1995. According to the 2019 Annual Report of the Institute of Labour Science and Social Affairs, among more than 13.4 million elderly people nationwide (aged 60 and over), there are 711,540 people receiving pensions from the budget, accounting for 5.31% [14]. Thus, the proportion of the elderly receiving pensions from the State budget accounts for a small percentage among the elderly only.

Pension from the Vietnam Social Insurance Fund: Those who have paid social insurance premiums for 20 years or more and reach the retirement age are entitled to a pension from the Vietnam Social Insurance Fund. However, the number of people receiving pensions from social insurance is not much in the total number of elderly people. Furthermore, the average amount that a person receives as monthly pension or social insurance benefit is not much. The average amount that a person receives as pension or social insurance allowance per month is less than 6 million VND [15].

**Table 3** In-patient experience at district-level hospitals varies by age (%)

| Age | * | ** | *** | **** | ***** | ****** | ******** |
|---|---|---|---|---|---|---|---|
| 50 | 97.8 | 94.4 | 94.8 | 1.8 | 93.6 | 95.1 | 96.6 |
| 50–54 | 100.0 | 93.1 | 94.8 | 3.4 | 96.6 | 92.0 | 89.8 |
| 55–59 | 97.7 | 97.7 | 97.7 | 0.0 | 97.7 | 92.7 | 92.1 |
| 60–64 | 100.0 | 93.5 | 95.7 | 4.3 | 97.8 | 93.2 | 92.1 |
| 65–69 | 98.0 | 98.0 | 93.9 | 0.0 | 98.0 | 94.7 | 97.1 |
| 70–74 | 97.8 | 95.7 | 93.5 | 4.3 | 97.8 | 100.0 | 100.0 |
| 75–79 | 97.4 | 94.9 | 97.4 | 2.6 | 89.7 | 93.3 | 100.0 |
| 80+ | 98.2 | 83.6 | 87.3 | 0.0 | 96.4 | 95.2 | 97.3 |
| Overall | 98.1 | 94.0 | 94.5 | 1.9 | 94.7 | 94.8 | 96.0 |

[*] Received daily check-ups; [**] Received explanation about diagnosis; [***] Received physician advice on what to do; [****] Treated with disrespect; [*****] Confirmed facility was clean; [******] Confirmed facility had sufficient equipment; [*******] Confirmed facility equipment functioned well
*Source* [4, 12]

Social retirement pension: The beneficiaries of social pensions include people from 60 to 79 years of age who are poor and live alone or with an elderly spouse and have no children or relatives to support; or people aged 80 and over without a contribution-based pension (as other two above).

In general, up to 64.42% of the elderly have neither pensions and nor other benefits. Therefore, a large proportion of the elderly are still working to generate income. Specifically, nearly 46% of people between the ages of 60 and 64; nearly 30% of people aged 70 to 79 and about 10% of people aged 80 and over are still working [16].

Another dimension of income is poverty. According to the assessment of the Ministry of Labour, Invalids and Social Affairs (based on the poverty criteria with an income of 1 million VND/person/month or less in rural areas and 1.3 million VND/person/month or less in urban areas), the poverty rate of people over 65 years old is 16.1% (compared with the national near-poverty rate at 14.5%) and increases to 17.1% for people over 70 years old [2]. To make matters worse, the elderly may experience physical and mental health problems, so older age groups spend more on health care compared to other age groups. As a result, a part of the elderly, especially the group with little pension, may experience financial difficulties after retirement.

In this study, we focus our analysis on the elderly in two key cities: Hanoi, Ho Chi Minh City (HCMC), due to their strong purchasing power and faster aging rate compared to rural area. In addition, we only focus on analyzing three most important categories to the elderly in order to gain deep understanding and be able to propose actionable recommendations.

## 3 Methods and Results

Mixed methods are employed to investigate older people's needs and solutions to serve those unmet needs. They include three phases: (i) Market survey to define top important categories towards elderly's life, (ii) In-depth interviews to understand the elderly's life, their insight and behavior, and define attributes in each category, and (iii) Quantitative survey to rank attributes by expectation in each category, and define gap of satisfaction for each attribute.

### *3.1 Phase 1—Market Survey*

**Objectives**: To define top important categories toward the elderly's life. As per quick market survey as above, this research aims to narrow down from the list of categories of products/services that can target the elderly to a few most important categories for deeper understanding in later research phases.

**Table 4** Respondents of the research

| Respondents | | Telephone calls | In-depth interviews | Surveys |
|---|---|---|---|---|
| Hanoi | Male | 20 | 4 | 36 |
| | Female | 20 | 4 | 39 |
| HCMC | Male | 20 | 4 | 36 |
| | Female | 20 | 4 | 39 |
| Total | | 80 | 16 | 150 |

**Table 5** Most important categories toward the elderly

| Categories | Importance |
|---|---|
| **Health and medical products/services** | **4.91** |
| **Specialized food and beverage for the elderly** | **4.75** |
| **Social interaction services and recreation activities (travel, music, sport…)** | **4.48** |
| Elderly care product (adult diaper, wheelchair, deaf-aid…) | 3.90 |
| Religious/charity activities | 3.82 |
| Residency | 3.57 |
| Legal consulting service | 3.46 |
| Non-medical home appliance (washing machine, microwave…) | 3.23 |
| Financial services | 3.13 |
| Transportation for the elder | 3.11 |
| Elderly apparel | 2.89 |

**Methods**: Quantitative survey by quick telephone call (n = 80, see Table 4). Questions (5-point scale): Which of the following categories of product/service do you find important for the current elderly life? Rate how important each category is. Using SPSS to analyse the data (Table 5).

**Results**: Top three most important categories are: Health and medical products/services, Specialized food and beverage for the elderly, Social interaction services and recreation activities (above 4 over 5).

Within the scope of this study and due to timing and budget constraint, this research will focus on these three categories in later phases of research for deeper understanding.

## *3.2 Phase 2—Qualitative Research*

**Objectives**: To deeply understand the behavior and insights of the elderly, as well as the needs in each of the three categories above.

**Methods**: In-depth interview (n = 16, see Table 4). Using content analysis to analyse the data.

**Key findings**: The elderly looking for in each category both materially and spiritually: Health and medical products/services, Specialized food and beverage for the elderly, and Social interaction services and recreation activities.

***Health and medical products/services***

Although they love to be taken care of by their child and grandchildren, they also don't want to be a burden. In the Confucius-influenced culture, one of the most important responsibilities of the child is to take care of his/her parents. However, with the modern life becomes busier and stressful for the working adult, and the new influence of western culture such as freedom and equality, the elderly also has a guilty feeling when their children spend a lot of effort taking care of them, in some case will make them feel useless and being a burden. Some verbatims are as follows (Table 6):

> My son, daughter-in-law and grandchildren are at work and school all day, so I do the cooking and cleaning so they will have a restful time when they come home—Mrs. Hanh, age 61, HCMC

> My son told me he will buy a massage chair to relieve my back pain, but I said no. I don't want him to spend too much money for me—Mr. Thanh, age 69, HCMC

> I've been denying an air-conditioning for my room for a long time, but my son decided to get one anyway. I was angry at first, but now my sleep was much deeper—Mr. Thang, age 59, Hanoi

> Every time my son taking care of me, I feel both happy and unhappy at the same time. On one hand, I was happy that he has me in his mind. On the other hand, I feel useless and taking too much of his effort—Mrs. Huong, age 71, widowed, Hanoi

***Specialized food and beverage for the elderly***

As having set aside many of their dreams and wishes when working to provide for the family, now it's their time to fulfill these regrets. With the Vietnam philosophy of prioritizing for children, the elderly had sacrificed their dreams and ambitions to focus on taking care of their son/daughter. Now their children have grown up and the elderly have the time (and money in some cases), but they often lack the health to make these wishes come true. Some verbatims are as follows:

> If it weren't for my kids, I would have gone to college—Mrs. Giao, age 60, Hanoi

> I love to travel to places, but I was entangled with children. Now I can go to wherever I want. Last year we just went to Thailand—Mrs. Trang, age 58, HCMC

> When I was a young man, I wanted to see every province of Vietnam, but I didn't have the time. Now I have time but cannot travel due to my health, and it costs a lot of money, so I "travel" by watching YouTube videos now—Mr. Trung, age 72, Hanoi

**Table 6** Health and medical products/services

| Types of attributes | | No | Attributes |
|---|---|---|---|
| Material | Product | 1 | Early disease detection |
| | | 2 | Right expertise for my medical need |
| | | 3 | Help to quickly response with emergency (e.g., stroke, seizure…) |
| | | 4 | Elder-friendly (easy to use, to maintain, comprehensive) |
| | | 5 | Respectful service |
| | | 6 | Modern and comfortable facility |
| | Price | 7 | Value for money |
| | | 8 | Convenience payment method |
| | Place | 9 | Easy to find/easy to approach |
| | | 10 | Easy delivery (for tangible product) |
| | Promotion | 11 | Recommended by expert or reliable person |
| | | 12 | Trusted and used by many people |
| | | 13 | After sales service |
| | | 14 | Can be tried before buying |
| Spiritual | | 15 | Give me and my family peace of mind |
| | | 16 | Feel cared |
| | | 17 | Feel respected |
| | | 18 | Eliminate suffering |

These insights are important for understanding the elderly, as well as serve as food for thought for further development on business ideas, both in concept stage and operational stages (Table 7).

***Social interaction services and recreation activities***

As the ability to learn new things has slowed down, they often perceived themselves outdated, which lead to indecisiveness. Although they are not unfamiliar with technology, they are only capable of doing basic task online and lack the ability of performing credibility check. Furthermore, they are often informed about various scam targeting the elderly. Therefore, they doubt the credibility of almost everything, often ask their child for opinion, and only trust expert such as doctors or mainstream media such as television. Some verbatims are as follows (Table 8):

> Technology happens so fast, some of them I can barely catch up with due to weak eyesight and slow hands. I often ask my grandson to help me to chat with my old friend via Zalo—Mr. Quang, age 68, Hanoi

> My daughter got me this hypertension measuring device. She assured my that her friend who is a doctor said this one is the most reliable—Mrs. Quyen, age 71, HCMC

> I have 2 billion VND in my saving account (approx. $87,000), but I still keep it there to gain interest. I've heard about the stock market and other investment stuffs, but I don't understand a thing, so I just keep my money in the bank for safety—Mrs. Binh, age 66, HCMC

**Table 7** Specialized food and beverage

| Types of attributes | | No | Attributes |
|---|---|---|---|
| Material | Product | 1 | Delicious |
| | | 2 | Fresh |
| | | 3 | Safe (no pesticide, no toxic chemical) |
| | | 4 | Supply basic nutrition |
| | | 5 | Offer specific nutrient for my need |
| | | 6 | Fit with elder diet |
| | | 7 | Variety of choices |
| | | 8 | Elderly-friendly packaging (easy-to-open, easy-to-read, easy-to-store) |
| | Price | 9 | Price can be bargained |
| | | 10 | Price suitable for long-term consumption |
| | | 11 | Value for money |
| | Place | 12 | Can choose my own item freely |
| | | 13 | Point of sales is nearby and popular |
| | | 14 | Have friendly human interaction |
| | Promotion | 15 | Recommended/endorsed by expert or reliable person |
| | | 16 | Communicated or used popularly |
| | | 17 | Have attractive promotion |
| Spiritual | | 18 | Leave good karma* |
| | | 19 | Environment friendly |
| | | 20 | Maintain family tradition** |
| | | 21 | Connect with the whole family |
| | | 22 | Giving extra care to loved ones |

* As some of them practices a vegan diet to avoid killing animals
** As some of them want to pass down the traditional way of cooking to younger generation

## *3.3 Phase 3—Quantitative Research*

**Objectives**: Rank the attributes in each category (defined in phase 2) by expectation and define the gap of satisfaction. Therefore, we can draw out the gap of satisfaction in each category.

**Methods**: Quantitative survey by questionnaire (n = 150, see Table 4). Questions (5-point scale): Among these attributes in each category, please rate how your expectation with each attribute. Among these attributes in each category, please rate how your current satisfaction with each attribute. We consolidate the mean score for each attribute, then the Satisfaction gap is calculated with the formulation: Satisfaction gap = Current satisfaction—Category expectation [17]. Using SPSS to analyse the data.

**Table 8** Social interaction services and recreation activities

| Types of attributes | | No | Attributes |
|---|---|---|---|
| Material | Product | 1 | Have fun |
| | | 2 | Pass the time |
| | | 3 | Learn new things |
| | | 4 | Privacy |
| | | 5 | Find someone who sympathizes with me |
| | | 6 | Variety of activities |
| | | 7 | Leisure/not adventurous |
| | Price | 8 | Affordable price |
| | Place | 9 | Easy to approach/to join in |
| | | 10 | Available both offline and online |
| | Promotion | 11 | Have attractive promotion |
| | | 12 | Many other elders also participated |
| Spiritual | | 13 | Feel belong |
| | | 14 | Leave legacy*** |
| | | 15 | Leave good karma |
| | | 16 | Feel needed/useful |
| | | 17 | Fulfill my wishes and dreams |
| | | 18 | Give me a sense of improvement |
| | | 19 | Give me a friend in need |

*** In activities such as charity, free teaching

**Results:** For expectation, this research focuses on attributes with the mean score of 4 or over. Among those attributes, this research zooms in the top five attributes with biggest satisfaction gap (as highlighted in Table 9).

***Health and medical products/services***

There is the biggest gap in the attribute "elderly-friendly," since there are barely any medical services in Vietnam that have laser focus on the elders, as medical test result/medical product often includes technical terms that the elderly cannot understand. The ability to "quickly response with emergency" also underperformed, due to the lack of proper training to family member for emergency and the traffic often hinder ambulance capability, therefore also affect the "peace of mind" attribute. The lack of state-owned specialized hospital results in the situation where the elders often have to go to crowded hospital with not-so-friendly staff (due to low wage), therefore the attribute "right expertise" and "respectful service" was also undersatisfied.

***Specialized food and beverage for the elderly***

As their health deteriorate and the fact that they have multiple chronic disease, their diet is required to be customized and far from similar to other family members, they

**Table 9** Satisfaction gap of health and medical products/services for the elderly

| Attributes | Category expectation | Current satisfaction | Satisfaction gap |
|---|---|---|---|
| Eliminate suffering | 4.63 | 4.14 | −0.49 |
| **Right expertise for my medical need** | **4.57** | **3.78** | **−0.79** |
| **Give me and my family peace of mind** | **4.54** | **3.13** | **−1.41** |
| Value for money | 4.51 | 4.01 | −0.50 |
| Early disease detection | 4.45 | 3.72 | −0.73 |
| Easy to find/easy to approach | 4.33 | 4.15 | −0.18 |
| **Help to quickly response with emergency (e.g., stroke, seizure…)** | **4.28** | **2.89** | **−1.39** |
| **Elder-friendly (easy to use, to maintain, comprehensive)** | **4.19** | **2.13** | **−2.06** |
| Feel cared | 4.14 | 3.90 | −0.24 |
| Feel respected | 4.12 | 3.53 | −0.59 |
| Recommended by expert or reliable person | 4.10 | 4.12 | 0.02 |
| Modern and comfortable facility | 4.07 | 3.35 | −0.72 |
| **Respectful service** | **4.04** | **3.18** | **−0.86** |
| *Trusted and used by many people* | 3.99 | 3.58 | −0.41 |
| *Can be tried before buying* | 3.74 | 2.19 | −1.55 |
| *Easy delivery (for tangible product)* | 3.70 | 3.55 | −0.15 |
| *Convenience payment method* | 3.48 | 4.03 | 0.55 |
| *After sales service* | 3.01 | 2.64 | −0.37 |

feel unsatisfied in the 2 attribute "Connect with the whole family" and "maintain family tradition". Furthermore, the underdevelopment of this category result in the big gap in "variety of choices" and "point of sales is nearby and popular". Some elders even lack the choices for their specialized meal, therefore create the gap in "Offer specific nutrient for my need" (Table 10).

***Social interaction services and recreation activities***

With the respectful culture toward the elderly, Vietnam society take quite good action in creating activities for the elderly social interaction need, result in the relatively small gap in top three most important attributes. However, these activities are simple and repetitive (physical exercise, playing chess), therefore the gap in "variety of activities" is big. Furthermore, current activities are only good at helping the elders to pass the time and having temporary fun, therefore the big gap remains in major spiritual attributes such as "feel needed/useful", "leave legacy", "give a sense of improvement" and "leave good karma" (Table 11).

**Table 10** Satisfaction gap of specialized food and beverage for the elderly

| Attributes | Category expectation | Current satisfaction | Satisfaction gap |
|---|---|---|---|
| **Connect with the whole family** | **4.69** | **3.59** | **−1.10** |
| Safe (no pesticide, no toxic chemical) | 4.58 | 3.74 | −0.84 |
| **Offer specific nutrient for my need** | **4.57** | **3.42** | **−1.15** |
| Price suitable for long-term consumption | 4.51 | 3.55 | −0.96 |
| **Variety of choices** | **4.49** | **2.84** | **−1.65** |
| Delicious | 4.47 | 4.01 | −0.46 |
| Fit with elder diet | 4.42 | 3.74 | −0.68 |
| Value for money | 4.40 | 3.91 | −0.49 |
| Have friendly human interaction | 4.32 | 3.95 | −0.37 |
| Fresh | 4.29 | 4.37 | 0.08 |
| **Point of sales is nearby and popular** | **4.25** | **3.12** | **−1.13** |
| Giving extra care to loved ones | 4.24 | 4.17 | −0.07 |
| Recommended/endorsed by expert or reliable person | 4.14 | 3.16 | −0.98 |
| Elderly-friendly packaging (easy-to-open, easy-to-read, easy-to-store) | 4.10 | 3.07 | −1.03 |
| **Maintain family tradition** | **4.10** | **2.92** | **−1.18** |
| *Leave good karma* | 3.96 | 3.05 | −0.91 |
| *Price can be bargained* | 3.94 | 3.26 | −0.68 |
| *Supply basic nutrition* | 3.91 | 4.03 | 0.12 |
| *Have attractive promotion* | 3.86 | 2.51 | −1.35 |
| *Can choose my own item freely* | 3.77 | 3.80 | 0.03 |
| *Communicated or used popularly* | 3.27 | 3.09 | −0.18 |
| *Environment friendly* | 3.04 | 3.02 | −0.02 |

# 4 Recommendations

## *4.1 Subscription Diet Tailor-Made for Each Elder*

**Context**: As the elderly grow old, their health status worsens, and many sicknesses demand special diet. According to a study of the National Geriatric Hospital in 2015, on average, an old person aged 80 or over suffered from 6.9 diseases, in which the four main diseases are cardiovascular diseases, diabetes, cancer, and chronic respiratory diseases, which all need specific diet.

There is no more one-size-fit-all meal for the whole family. Cooking their own meal separately is the current best option, but they have to buy many extra ingredients and it takes a lot of effort, while letting their children cook for them makes them feel

**Table 11** Satisfaction gap of social interaction services and recreation activities for the elderly

| Attributes | Category expectation | Current satisfaction | Satisfaction gap |
|---|---|---|---|
| Feel belong | 4.92 | 4.14 | −0.78 |
| Many other elders also participated | 4.77 | 3.81 | −0.96 |
| Leisure/not adventurous | 4.75 | 4.69 | −0.06 |
| **Variety of activities** | **4.53** | **3.01** | **−1.52** |
| Have fun | 4.51 | 4.10 | −0.41 |
| **Feel needed/ useful** | **4.31** | **3.15** | **−1.16** |
| Find someone who sympathizes with me | 4.27 | 3.34 | −0.93 |
| Fulfill my wishes and dreams | 4.26 | 3.36 | −0.90 |
| **Leave legacy** | **4.20** | **2.30** | **−1.90** |
| Pass the time | 4.12 | 4.19 | 0.07 |
| **Give me a sense of improvement** | **4.11** | **2.03** | **−2.08** |
| **Leave good karma** | **4.08** | **3.07** | **−1.01** |
| Affordable price | 4.06 | 3.21 | −0.85 |
| Learn new things | 4.05 | 3.31 | −0.74 |
| Give me a friend in need | 4.01 | 3.67 | −0.34 |
| *Easy to approach/to join in* | 3.98 | 3.15 | −0.83 |
| *Have attractive promotion* | 3.79 | 2.55 | −1.24 |
| *Privacy* | 3.51 | 3.02 | −0.49 |
| *Available both offline and online* | 3.23 | 2.11 | −1.12 |

like a burden. Hence the big satisfaction gap in the attribute "Offer specific nutrient for my need" in the quantitative research phase.

The variety of dishes is also low (−1.65 points of satisfaction gap). In many cases, the doctor says something is good, then their child makes them have the same dish for a whole week. Also, while they cannot eat the same food as their child and grandchildren, they still enjoy the feeling of connection in the family meal and don't want to eat separately. Currently gap −1.10 points in "Connect with the whole family" and −1.18 points in "Maintaining family tradition".

**Action**: The 3-meal-a-day subscription diet, deliver to their doorstep. As for input information of each elder's health and recommended diet, the companies and/or the one who are interested could partner with doctors and hospital/state-owned nutrition center to get recommended nutritional level for each specific macronutrients and micronutrients, right after the elders have finished their scheduled medical check-up. The service will also be recommended by doctors.

As for the meal, the company could apply AI-created menu, base on a library of Vietnamese rich cuisine culture and customize according to the elder's nutritional

need, to recommend diverse options of dishes and fit with Vietnamese taste for each elderly person.

**Expected result**: Material benefit: a convenient, varied, balanced and healthy diet for the elderly. Spiritual benefit: the child can have a sense of filial piety to their parents when he/she buy the subscription for his/her parent. The elderly can still enjoy the connected feeling of the family meal while do not feel like being a burden.

## *4.2 Health Companion*

**Context**: Most of the elderly has a chronic disease which need frequent tracking, in some cases on a daily basis such as hypertension, diabetes.

While they just need to be sure that everything is still fine, coming to the hospital frequently posed as a lot of hassle (gap −0.86 points in "respectful service"), while hiring an in-home maid is costly, often lack medical expertise and makes family members uncomfortable because of the presence of a stranger.

Meanwhile, what they needed the most is to prevent the risk and react in case of emergency (e.g. stroke, seizure…), in which the loved ones are prone to panicking, which lead to the waste precious early first aid time (gap −1.39 points in "Quickly response with emergency"). This creates a constant sense of fear that an emergency will come suddenly, hence the gap −1.41 points in "Peace of mind".

**Action**: A system with the core being a mobile or wearable device on the elder, synchronized with camera, always-on support center to keep track of their vital signs. In case of emergency such as stroke or seizure, it will alert the nearest emergency service to give urgent first-aid guidance, while the medical team come and handle the situation.

The service is based on a subscription model and shared economy, in which the elderly who is not yet in emergency will cover the cost of the unlucky few. The cost is for the tracking and emergency alert (giving right assistance at the right time), while the medical cost is a separated part which will be paid directly to the hospital by the user.

**Expected result**: Material benefit: tracking chronic disease and provide right medical assistance at the right time. Spiritual benefit: the child can have a sense of filial piety, while both the elderly and the child feel safe and enjoy the peace of mind.

## *4.3 Senior Digital Hub*

**Context**: While the elderly are the time billionaires, there entertainment activities are repetitive (gap −1.52 points in "variety of activities").

In Vietnam there is barely any specialized content hub for them, either on television or digital platforms. While there are internet-connected smart TVs in almost all urban families, the content for the elderly is still lacking, and most of the content such as newspaper is not elder-friendly (too small fonts, the use of too many new words…). This makes them feel outdated in this fast-changing world, and constantly asking their children make them feel helpless. However, they love the feeling of the kids being amazed when their grandparents know a lot of new and modern things. Therefore, this is the urgency to create a platform for the elderly to participate and give them spiritual satisfaction, by closing the gap in spiritual attributes such as usefulness, leave legacy, having a sense of improvement.

**Action**: A visual and audio content hub specialized for the elderly, primarily on YouTube. The content includes but not limited to health care advice, living a healthy and positive lifestyle, cooking instruction, travel content, introduction of new knowledge, as well as review and shopping for the elderly products. There will be expert such as doctor, state agency representative, fellow elderly to build credibility.

For the time being, with the high internet penetration in the elderly group but not yet being tech-savvy, the main interaction is between them and the hub administrator, and occasionally contribution of elders themselves (Guest in some video, charity donation, offline events…). For the long-term vision, such as in the next 10 years when people born in the 1970s become the new elders, they can actively contribute content such as sharing their life experience and profession to the youth.

**Expected result**: Material benefit: stay connected, updated and informed. Being entertained. Spiritual benefit: Self-improvement, useful. In the long term this may even include leaving legacy.

## 5 Conclusion

The aging population in Vietnam has a growing and substantial impact on socio-economic development. The market for the elderly in Vietnam is not yet ready to serve the needs of the rapidly aging population. This poses a challenge to society, but on the other hand also creates an opportunity for business to develop and thrive by serving diverse unmet needs in this growing segment.

The research examines the issue of population aging in Vietnam, reviews relevant literature, and proposes practical measures to address the challenges facing older individuals in the country.

Three recommendations are developed based on the synthesis of the above initial qualitative and quantitative research results. In the later phases, the companies and/or the one who are interested will dive deeper into the feasibility checks, building business model as well as analyzing key business metrics for potential ideas.

These ideas are based on the understanding of the elderly at the present time (2022), but with the forecasted population pyramid for 2029, the proportion of elderly people will increase in the population structure (thanks to healthcare development

extending life expectancy and decreasing birthrate), the elderly consumer group will increase in quantity and the business potential in this segment for the period 2021–2030 would keep increasing.

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# Harmonious and Obsessive Passion Influence Consumers' Support for Technology Products Through Brand Addiction

**Minh Thi Hong Le, Thao Kim Nguyen, and Nguyen Hoang Thuan**

**Abstract** Brand addiction has recently been conceptually developed and scaled up. Brand-addicted customers constitute a valuable market segment for brands, particularly in Vietnam due to the increased number of consumers shifting from buying unbranded products to branded ones. However, little research has investigated the factors influencing brand addiction and its outcomes. Adopting the dualistic model of passion, this research develops a model to predict harmonious and obsessive passions as key antecedents of brand addiction and highlights the loyal behavior of consumers to support a brand after a scandal as its key consequence. This study was accomplished with Vietnamese consumers who had bought technology products through e-commerce. The proposed model was tested with 417 questionnaire respondents. Internal consistency, composite reliability, convergent validity, and average variance extracted were assessed to validate a reflective measurement model. Finally, SmartPLS 3.0 software was used to analyze the structural equation modeling of the research model. The findings of this study illustrate the benefits of efforts aimed at increasing consumers' emotional connections with brands. Practitioners can find the results of the study valuable to manage the relationship with their consumers from the emotional perspective.

**Keywords** Brand addiction · Technology products · Behavioral research

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## 1 Introduction

The consumer-brand relationship centers around commitment and loyalty. Recently, researchers have categorized additional brand constructs with increasingly intensive emotional connections, such as brand attachment [1], passion [2], love [3], and addiction [4]. Brand addiction is found in consumers who are addicted to using or consuming the products of a particular brand; its features include bonding, brand exclusivity, a strong desire and compulsive urge to acquire a brand's products, and a lack of self-control [4]. It is essential to understand brand addition as it can engender both positive and negative outcomes. Brand addiction exists in many consumption fields, in which brand personality is closely linked to consumer self-identity, such as music, sports, motorsports, and fashion apparel [5].

Previous research has developed a scale, construct, and characteristics of brand addiction [4] and identified brand hedonism, brand self-expressiveness, brand innovativeness, and brand authenticity as its antecedents [6]. Brand addiction is also strongly associated with compulsive purchasing, brand exclusivity, and life satisfaction [4]. For instance, whenever Apple introduces a new product, committed customers are eager to purchase it [7]. Sometimes, addicted individuals are willing to pay a higher price for their preferred brand's merchandise in order to satisfy their compulsive behaviors [8]. However, there are few studies on causes and effects of brand addiction.

Vietnam is a market providing an appropriate context to investigate attitude toward brands since the consumers have changed their shopping habits from buying unbranded products to acquiring branded ones [9]. Vietnamese consumers become more concern of brand information and they spend considerable amount of time researching information on brands, 12% higher than the global average [10]. Participating in the global economy since 1986, branded products have made their ways into the country, which results in a variety of branded products in the market [11]. Further, the consumption of branded products in the country has been seen as a sign for material achievement [12].

However, there is limited study on drivers and effects of brand addition in Vietnam. Understanding the factors that drive brand addiction can fill this gap in the literature and provide brand managers with theoretical evidence to inform their strategies for high-intensity emotional consumers. Determining the consequences of brand addiction will also illustrate the benefits of efforts aimed at increasing consumers' emotional connections with brands.

This study adopts the dualistic model of passion to address the identified gap. The dualistic model of passion explains that passion comes from two factors: harmonious and obsessive passion [13–15]. While previous studies have shown that passions can lead to brand addiction behavior, it has not shown which type of passion leads to brand addiction nor has it shown whether the impact of each passion type on brand addiction is different or not. In addition, brand addiction is an extreme form of emotion that leads to positive and excessive (negative) behavior. Whether brand addition can influence the consumers' supportive behavior after a scandal have not

been sufficiently explored. Thus, whether the two forms of passion affect brand addiction in different ways, and whether brand addiction affects consumers' behavior to continue support it after scandals needs further exploration. This study will address these gaps in Vietnam context.

The paper is structured as follows. In the next section, the dualistic model of passion and attachment theory are introduced in the theoretical background to serve as the foundation for two types of passion leading to brand addiction. This section also develops research hypotheses about the passion-created antecedents of brand addiction and explains how brand addiction affects willingness to support a brand after a scandal. Section 3 presents how to gather data and the genesis of research scales and analysis procedures. The analysis and results of the study will be presented in Sect. 4. The paper concludes with a discussion of its theoretical and managerial contributions, research limits, and future research.

## 2 Theoretical Background and Conceptual Development

### *2.1 The Dualistic Model of Passion*

The Dualistic Model of Passion is adopted to make the theoretical foundation for our research model. In this theory, passion is demonstrated by a strong proclivity for an activity that people value, and to which they devote their time and energy. According to the Self-Determination Theory [16], humans are inclined to internalize and integrate external behavioral rules to feel self-determination. Consumers can regulate their conduct despite their enthusiasm, which is harmonious passion. Connected or not, individuals must have a feeling of belonging to themselves and to others. Especially for brand junkies, the sense of belonging to the brand community and participation in brand activities is their motivation and passion. By and large, we can further classify two types of passions: harmonious passion and obsessive passion [13–15].

*Harmonious passion* is considered a result of the independent internalization of behavioral rules, which produces a strong desire to engage in an activity. However, with harmonious passion, the individual can control their interest and desire and make decision whether to spend their resources for an activity. Therefore, this type of passion creates a sense of choice and personal responsibility for engaging in the activity. As a result, the significance of the activity is openly acknowledged, with no strings attached. The activity is consistent with other aspects of the self and is thoroughly integrated into the true self of the individual [13]. Internalization occurs when people feel independent, connected, and competent. With a harmonious passion, people follow their norms and engage in their passionate interests and other activities with an openness that encourages good experiences [14]. As a result, such an individual may participate in a chosen activity with greater flexibility and awareness.

*Obsessive passion* arises from a lack of satisfaction with inner desires, which leads to the internalization of intra- or inter-personal pressures. Individuals acquire an ego-invested or false self-foundation on external circumstances in unsupportive contexts. An obsessive interest leads to participation in an activity, which is viewed as a replacement for self-worth [15]. As a result, the activity is pursued eagerly and enthusiastically because of the comfort and ego-affirming moments it creates [17]. As implying, an activity that has an ego invested will be pursued rigorously.

Generally, the formation of the individual or societal self may be independent or regulated, and the ensuing brand passion may be harmonious or obsessive. This study will consider the relationships between dualistic passion and brand addiction models and aims to investigate the mediating role of brand addiction between the relationships of these two types of passion and consumer support for a brand after scandals [18].

## *2.2 Brand Addiction*

In the consumer-brand literature, there is a significant expansion of examining constructs such as brand attachment and brand passion. The examination of emotional attachment of brand has not been adequately explored. Therefore, additional research is required to investigate the effect of such attachment on consumer's behavior, one of which is brand addiction. The Cambridge online dictionary defines addiction as "the need or strong desire to do or to have something, or a very strong liking for something which is an inability to stop doing or using something". According to Fournier and Yao [19], the conceptualization of brand relationship quality is comparable to the relationship quality construct. In this logic, the relationship between a consumer and a brand reflects the intensity of connection along a similar continuum, starting with non-intense emotions and ending in addictive obsession.

Brand addiction involves acquisitiveness, dependence, follow-up, hoarding, lack of self-control, obsession, outward influence, persistence within affordability, resistance to substitutes, support, and thought occupancy. Brand addiction is furthermore focused on a specific brand and expands upon both the consumer-brand relationship and addictive consumption. Addicted consumers fail to control themselves from purchasing products from their favorite brands [1] and can find themselves thinking frequently about their favorite brand, giving up occupational, academic, and familial activities and duties in favor of activities related to their favorite brand. Passion can drive addicts to possess more of their favorite brand's products and make sacrifices for desired objects [20].

## *2.3 Research Model*

**Harmonious and obsessive passion as antecedents of brand addiction**

Brand passion refers to the intensity of emotion when consumers have a deep experience with or commitment to a brand and can include both harmonious and obsessive passion [2]. Through such passionate consumption, consumers can express their intense emotions. Passion is a motivating factor for arousal forms that interact reciprocally with intimacy but has also been suggested to significantly influence the emotional relationship that consumers establish with products and brands.

With a harmonious passion (HP), a consumer's self-identification is aligned with a brand. Possession of the brand's product would induce feelings of satisfaction without supplanting the consumer's identity [8]. Therefore, HP should buffer the connection between adoration and brand addiction, leading to the following hypotheses:

**H1** Harmonious passion is positively associated with brand addiction.

On the other hand, obsessive passion (OP) is the internalization of an activity that is due to the internal pressure to develop self-worth [2]. Recent literature suggests that brand addition is closely related to forms of passion, in which participation feels obligatory or even compulsive [21]. Obsessive passion for activities may be experienced as addiction. Passion in brand addiction concerns a feeling of longing for the brand. For example, consumers experiencing such feelings actively follow brand news, visit brand stores or websites [22], and are consistently ready to buy from the brand. Thus, we proposed the following hypothesis:

**H2** Obsessive passion is positively associated with brand addiction.

**Willingness to support a brand after a scandal as consequence of brand addiction**

Brand scandals, which originate from both product failures and brand-endorsed scandals [23], can destroy a brand's reputation [24]. However, a strong emotional relationship between a brand and its consumers helps consumers forgive product errors [25]; additionally, many customers believe in the improvement of brands they love or are addicted to [26]. In addition to the brand being harmed by issues with the product or the marketing message being presented incorrectly. Celebrities with personalities that match brand identities are frequently contracted by brands to advertise their products [23]. If such celebrities are involved in scandals, however, a brand's reputation can be indirectly impacted. When people are aware of scandal, yet too loyal and determined to punish the offenders, this kind of discrepancy can arise [27]. In either situation, the brand's addicted customers are more likely to forgive wrongdoings, as long as the brand is honest about its errors and provides customer support. Given this understanding, we hypothesized:

**H3** Brand addiction is positively associated with willingness to support after scandal (Fig. 1).

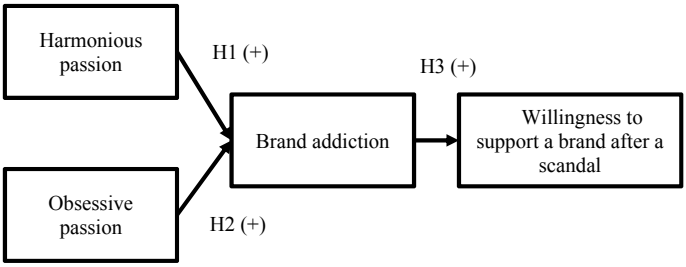


**Fig. 1** Research model

## 3 Methodology

### *3.1 Sample*

The study was conducted in Vietnam, focusing on the purchase of apparel (61%), cosmetics and personal care products (45%), information technology and portable devices (38%), and consumer electronics (36%). This is a promising market because the Vietnamese economy is growing rapidly [28], specifically for technology products [29] and phone products from Apple and Samsung [30]. Additionally, Vietnamese consumers want to use brands to convey themselves to society, and some use innovative technological products because of their personal connection [31]. The questions are translated from English to Vietnamese and then back to English using the technique of reverse translation. Screening questions were used to identify the intended audience, such as "Do you buy, use, or intend to buy any technology equipment?" If the respondent indicates "no,", they will be thanked for considering participation. If the respondent replies "yes,", they will be invited to continue responding. First, we administered the questionnaire to ten students and staff members who had purchased at least one electronic device within the previous three to four months. The objective is to ensure that they comprehend the intended meaning of the question. After modifying a few words per the suggestions, we began collecting data on a larger scale. Data were collected at high-density locations, including middle schools, colleges, universities, supermarkets, and convenience stores. Respondents will receive an online English learning eBook via email or a link with QR code scanning as a token of appreciation. In addition to demographic inquiries, respondents answered questions about their gender, age, education, and monthly income. The survey yielded a total of 432 respondents; however, we eliminated 15 responses because they were incomplete. There are 417 valid questionnaires in total (96.52%). Table 1 displays the demographic information of the respondents.

**Table 1** Demographic information

| Items | Frequency | % | Items | Frequency | % |
|---|---|---|---|---|---|
| *Gender* | | | *Age (years)* | | |
| Male | 209 | 50.1 | <25 | 66 | 15.8 |
| Female | 204 | 48.9 | 26–35 | 145 | 34.8 |
| Other | 4 | 1.0 | 36–45 | 160 | 38.4 |
| Brands | | | >45 | 46 | 11.0 |
| Shopee | 116 | 27.8 | Education | | |
| Tikki | 89 | 21.3 | Primary | 3 | 0.7 |
| Apple | 68 | 16.3 | High school | 21 | 5.0 |
| Samsung | 38 | 9.1 | Vocational degree | 169 | 40.5 |
| Lazada | 26 | 6.2 | Undergraduate | 153 | 36.7 |
| Others | 80 | 19.2 | Post-graduate degree | 71 | 17.0 |

### *3.2 Measurement*

The study model was assessed using measures that were drawn from the literature. Harmonious passion (HP) and obsessive passion (OP) were measured using the scales of four items and seven items, respectively from Vallerand et al.' study [2]. Willingness to support after a scandal (WTS) was measured using four items from Loureiro's study [20]. The 7-point scales with the same indicators were utilized for all measurements (strongly disagree, disagree, somewhat disagree, neither disagree nor agree, somewhat agree, agree, and strongly agree). The assessment for the measurement model follows the strategy suggested by Hair et al. [32].

## 4 Analysis and Findings

### *4.1 Reliability and Validity of the Measurement Model*

We tested our proposed model using partial least squares structural equations (PLS-SEM) [32]. To examine a reflective measurement model, we checked internal consistency (i.e. Cronbach's alphas were higher than 0.70, and composite reliability varied between 0 and 1) (Table 2). We further checked convergent validity (i.e. standardized loadings were above 0.70, and the average variance extracted (AVE) was higher than 0.50) [33] (Table 2), which was assessed through the AVE of each construct. All AVE values were higher than 0.5 [34]. In the test for discriminant validity, the heterotrait-monotrait ratio (HTMT) was significantly below 1, which shows the distinctiveness of the constructs (Table 3). The HTMT is a reliable criterion for discriminant validity since it requires computing bootstrapping confidence intervals with 5,000 resamples

[32]. According to Khalilzadeh and Tasci [35], in addition to the p-value and alpha levels, it is crucial to examine effect sizes (f-square). In this examination, results that are smaller than 0.15 is considered a "small" effect; results that are over 0.15 are considered "good enough" or a moderate effect; and results that are greater than 0.30 is considered a "large" effect. However, Hair [34] and Henseler et al. [36] suggest that f-square ($f^2$) values above 0.5 and 0.02 can be considered strong and weak, respectively.

### *4.2 Hypothesis Testing*

We further tested the proposed hypotheses. We started with the collinearity assessment tests for the variance inflation factor (VIF), which should have values below 5. Our test results show that all VIF values were below 5. We further examined the coefficients of determination $R^2$ (explained variance) and $f^2$ (effect size) that predict capabilities and relationships between the constructs [34]. The results are presented in Table 4. According to the $f^2$ results, the OP variable has a significant impact on BA ($f^2 = 0.398$), which is more than two times larger than the relatively weak effect of HP on BA ($f^2 = 0.112$). Next, BA has a strong impact on WTS ($f^2 = 0.546$) (see Table 4). Further, the $R^2$ value for WTS was 0.353, which indicates that brand addiction (BA) explains 35.3% variation of willingness to support after a scandal. Meanwhile harmonious passion and obsessive passion explained 39% variation of brand addiction.

The hypothesis testing results are presented in Table 4. In particular, brand addiction was better explained by harmonious passion ($\beta = 0.506$, $p = 0.000$, 95% CI = 0.427–0.508) than by obsessive passion ($\beta = 0.269$, $p = 0.000$, 95% CI = 0.182–0.356). H1 and H2 were supported. The impact of brand addiction on willingness to support was also statistically significant ($\beta = 0.594$, $p = 0.000$, 95% CI = 0.530–0.657); therefore, H3 was also supported.

## 5 Discussion and Conclusion

### *5.1 Theoretical Implications*

From a theoretical perspective, the study results show the role of the dualistic model of passion theory providing a critical theoretical foundation to explain the effects of different types of passions on consumers' behavior to support a brand through brand addition. Previous research in the consumption context has highlighted the importance of passion affecting consumer behavior toward a brand [4, 6, 37]. The current findings further suggest that different types of passion, which are harmonious passion and obsessive passion can both lead to intensive emotional bonds with brands,

**Table 2** Reflective measurement model results

| Variable | Item (adopted from [2, 20]) | Loading |
|---|---|---|
| *Brand addiction (BA) AVE* = 0.640; *Cronbach's alpha* = 0.930; *CR* = 0.931 | | |
| BA1 | "I try very hard to get everything from my favorite brand" | 0.805 |
| BA2 | "I often fail to control myself from purchasing products of my favorite brand" | 0.779 |
| BA3 | "I often find myself thinking about my favorite brand" | 0.785 |
| BA4 | "I tend to give up some life activities and duties such as the occupational, academic and familial in order to fulfil some activities related to my favorite brand" | 0.805 |
| BA5 | "I tend to allocate certain portion of my monthly income to buy the products of my favorite brand" | 0.794 |
| BA6 | "I usually remember tenderly the previous experience with my favorite brand" | 0.810 |
| BA7 | "I experience a state of impatience immediately before I can get hold of the products of my favorite brand" | 0.844 |
| BA8 | "I follow my favorite brand's news all the time" | 0.788 |
| BA9 | "I usually plan when the next purchase of my favorite brand will be" | 0.789 |
| *Harmonious passion (HP) AVE* = 0.774; *Cronbach's alpha* = 0.902; *CR* = 0.912 | | |
| HP1 | "This activity allows me to live a variety of experiences" | 0.884 |
| HP2 | "The new things that I discover with this activity allow me to appreciate it even more" | 0.915 |
| HP3 | "This activity allows me to live memorable experiences" | 0.890 |
| HP4 | "I try to keep my life simple, as far as possessions are concerned" | 0.827 |
| *Obsessive passion (OP) AVE* = 0.760; *Cronbach's alpha* = 0.947; *CR* = 0.950 | | |
| OP1 | "I cannot live without it" | 0.796 |
| OP2 | "The urge is so strong. I can't help myself from doing this activity" | 0.889 |
| OP3 | "I have difficulty imagining my life without this activity" | 0.908 |
| OP4 | "I am emotionally dependent on this activity" | 0.887 |
| OP5 | "I have a tough time controlling my need to do this activity" | 0.883 |
| OP6 | "I have almost an obsessive feeling for this activity" | 0.901 |
| OP7 | "My mood depends on me being able to do this activity" | 0.828 |
| *Willingness to support after a scandal (WTS) AVE* = 0.852; *Cronbach's alpha* = 0.942; *CR* = 0.943 | | |
| WTS1 | "I would continue to support this brand" | 0.916 |
| WTS2 | "The brand should be allowed to remain in the market" | 0.941 |
| WTS3 | "I would contribute to this brand's campaign" | 0.910 |
| WTS4 | "I would feel comfortable wearing a T-shirt in support of the brand" | 0.926 |

**Table 3** Confidence intervals for Heterotrait-monotrait ratio of correlations (HTMT)

| | BA | HP | OP | WTS |
|---|---|---|---|---|
| BA | | | | |
| HP | 0.411 | | | |
| OP | 0.601 | 0.231 | | |
| WTS | 0.633 | 0.409 | 0.400 | |

**Table 4** Hypotheses results

| Hi | Relations | β | St.dv | t-values | Effect size ($f^2$) | Results |
|---|---|---|---|---|---|---|
| H1 | HP → BA | $0.506^{***}$ | 0.039 | 12.847 | 0.112 | Supported |
| H2 | OP → BA | $0.269^{***}$ | 0.044 | 6.065 | 0.398 | Supported |
| H3 | BA → WTS | 0.594*** | 0.033 | 18.134 | 0.546 | Supported |
| *Mediation testing results* | | | | | | |
| | HP → BA → WTS | $0.160^{***}$ | 0.029 | 5.506 | | Supported |
| | OP → BA → WTS | $0.301^{***}$ | 0.030 | 9.913 | | Supported |

*Notes* t-value should be greater than 1.96 to be significant at <0.05
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

such as brand addiction. Obsessive passion may lead consumers to buy more products. To some extent, consumers who rely heavily on self-image via brand consumption may easily be passion-obsessed with a brand [17], leading to brand addiction.

In addition, when comparing the influence of obsessive passion and harmonious passion on brand addiction, the latter had a more significant impact. These findings highlight the significance of brands in reflecting, connecting with, or fostering consumer passion. Compared with previous studies [1, 20], this study results extend the impact of dual passion theory that can create brand addiction in both positive and negative aspects. While the positive aspects are driven by the effect of harmonious passion on brand addiction, the negative effects of the extreme emotional state of brand addiction are attributed to obsessive passion. Therefore, this research adds to the knowledge by revealing an emotional link between brand passion and brand addiction. The findings also differentiate the effects of two types of brand passion toward brand addiction, two ideas that have not been defined clearly in previous studies.

This study highlights several contributions to consumer-brand relationships and offers insights into brand attachment. In particular, it suggests that strong brand attachment may lead to addictive behaviors. This study suggests that positive feelings can urge consumers to forgive brand scandals. As so, companies should build up strong brand connections, which can maintain loyal customers and thus create a team that always protects the brand. Additionally, brand addiction can urge loyal consumers to buy more products to satisfy their possessive feelings.

Regarding consequences, this research investigates brand addiction's influences on willingness to support after scandal, filling the gap mentioned in Mrad and Cui [38]. This study also expands on the consequences of brand addiction by highlighting consumers' loyalty behavior in the Vietnamese context. A new consequence of intensive emotional relationships with brands is highlighted: the willingness to support a brand after scandal. This research shows that addicted brand consumers who appear willing to support a brand after a scandal are the most trustworthy type of consumers. They remain with the brand in any situation; thus, they are the most effective channels for advertising and attracting new potential consumers within their network [4].

## *5.2 Practical Implications*

From a practical perspective, we find that if consumers are passionate about a brand, they become addicted to the brand. Thus, managers can develop ways to interact with customers and take the relationship between consumers and the brand to a higher emotional level. In brand management, harmonious passion can play the leading role in creating a level of brand passion [1]. Meanwhile, development of brand addiction will be affected by obsessive desire. Obsessive passion can create an extremely negative emotional state and ultimately be somewhat harmful to the consumers. With this knowledge, brand managers should encourage restrained buying behavior from consumers exhibiting harmonious obsessive passion, such as by organizing brand activities at appropriate times, or by encouraging customers to buy in combos but limiting the number of times one customer can buy to somewhat restrain the customer's potential feeling of being urged to buy uncontrollably, which can arise from obsessive passion.

Advertising should emphasize the uniqueness of brand identity, which can boost consumer identification through proactive and positive activities [39]. Additionally, building trust is key to inducing consumer passion [8] and pride in the brand when using its products. Managers should also (1) use messages that confirms the brand will accompany loyal consumers in their life activities; (2) display care for consumers' communities, peers, or families; and (3) enhance consumers' lives to reduce obsessive passion, which can lead to extreme behaviors. Managers should prepare plans for handling such extreme behaviors to avoid negative impacts on the brand image.

The consequences of addiction show that addicted customers often easily forgive any brand scandals that occur. This should increase managers' confidence and motivation for taking care of this group of customers, as they are always there to support the brand no matter what happens. Therefore, brand managers should have separate customer care policies for this customer group, such as allowing them to be the first to buy new products or enjoy preferential discounts. A brand can organize activities specifically for this group of customers, such as co-creation activities, soliciting ideas from those who love or are addicted to the brand. New product features, with contributions from these particular customers who know the brand best, will clearly

show the brand's personality and help overcome existing problems with the product or service.

### *5.3 Future Research*

The study's shortcomings provide options for further investigation. The current data were obtained in the content of single country, i.e. Vietnam. In the future, researchers should look at data from more than one country to see how well the results apply to different contexts. Future research might gather longitudinal data to extend the existing results. This study also asked respondents to rate their favorite brands, but in the future, different brand communities might be asked for information. Future research should also look into the bad things people do when they are addicted to a brand [4], like vandalism or badmouthing competitors [40, 41], or making angry comments on Internet forums [42] when they are willing to support a brand after a scandal. Moreover, it is essential to evaluate how brand addicts see competing brands. In the future, researchers could also look into the negative parts of brand addiction. They could find the warning signs and let brand managers know that brand addicts may do bad things that hurt the company's reputation [43, 44]. Lastly, brand love has a lower emotional level than brand addiction. In the future, researchers should look into what causes brand love to turn into brand addiction.

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# Explanation of a Sustainable Digital Transformation Process in a Firm


**Duong Dang, Tero Vartiainen, and Thai Do**

**Abstract** We are living in the digital era, in which firms often face many challenges due to the rapid development of digital technologies. Thus, firms need to reform their traditional business models by integrating digital technologies into all areas of existing business processes for their survival. This integration process is called digital transformation (DT). However, the understanding of how to develop a sustainable DT process for firms remains incomplete and fragmented. As a result, we studied how DT unfolds over a period of years in the case of telecenters (TCTs) in the context of sustainability. We used a qualitative case study as our research approach. We contribute to the literature by introducing a model of a digital transformation process and its relationship with sustainability. We also contribute to practice by suggesting that in order to ensure sustainability for the long term, managers need to prioritize the sustainable factors in each phase of the DT process while maintaining, continuously seeking, and implementing new digital initiatives.

**Keywords** Sustainability · Digital transformation · Telecenters · Case study

## 1 Introduction

Digital transformation refers to the process of integrating digital technologies into businesses [1, 2], helping organizations take advantage of digital technologies and transforming their business model [3]. As a result, understanding DT is important for both academics and practitioners [4, 5]. Digital transformation *may occur in various*

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*scenarios, such as being part of a firm's plan* [6] or in an unexpected *situation* [7]. *This* is because digital technologies involved in DT seem to have more generative, malleable, and combinatorial properties compared to traditional information technology (IT) [8]. In addition, the boundaries of digital technologies are more open, flexible, and ubiquitous compared to traditional IT [9]. This may explain why so many DTs fail [10].

Recent literature has called for a greater understanding of DT at the micro level (c.f. [6]) to help firms achieve sustainable DT [11, 12]. Here, sustainability includes the natural environment, society, and economic performance components [13]. In other words, besides economic performance, the other two components are equally important for a firm to achieve sustainability. Thus, this paper studies sustainable DT. We particularly answer the research question: How does a firm develop a sustainable digital transformation process?

We used an interpretive case study as the research approach. The data collection for this study included three main sources: secondary data, a survey, and interviews. We contribute to the literature by providing a sustainable DT process model for firms. In particular, DT is a never-ending process that can be triggered and shaped by digital technologies, regulations, and competitions. Under these pressures, digital initiatives are formed and implemented at the subsystem level. After that, best practices are chosen to be implemented in a wider range at the organizational level. Digital initiatives are then refined, revised, or new ideas continue to be implemented at the subsystem level, and the process continues. From the perspective of sustainability, economic factors are the most important in every step of the DT process. Social and environmental factors are equally important, especially in the implementation phase. However, as evidenced by this study, a firm could not achieve social and environmental factors if it did not receive support from other shareholders, such as the government, in this case study. The government establishes friendly policies that help firms contribute to other factors while maintaining appropriate revenue.

## 2 Theoretical Background

### *2.1 Digital Transformation and a Sustainable Digital Transformation Model*

Digital transformation is increasingly considered an important socio-technical concept in information systems (IS) literature [14–16]. Organizations transform their business models based on digital technologies. Digital technologies refer to systems, tools, devices, technologies, and resources that generate, process, or store information [3, 17, 18]. Information systems scholars mainly focus on the application and impact of digital technology, rather than on digital technologies on their own [19, 20].

There are different views of DT. For example, it may refer to organizational changes using certain digital technologies, or even using any information technologies or systems [1, 2]. The scopes of DT also range from organizations to industrial to societal [2, 6, 21]. Another view is that DT has four main properties: (i) target institution, to indicate where DT is taking place; (ii) scope, to indicate where the changes are taking place; (iii) means, to indicate where the technologies are involved; and (iv) expected outcomes, to indicate the outcomes of DT [7]. Digital transformation can be intended by and takes place within the boundaries of an organization [6, 7]. However, it is argued that, in reality, DT is not necessarily initially intended from inside an organization. This is what we view as DT in this paper. Different DT models have been discussed in the literature in the context of established companies, digital companies, the public sector, and developed counties [22, 23]. For example, DT models in the public healthcare sector need to put aside economic factors [24], while the economy is a critical factor in companies or sectors that are market-driven [25]. Moreover, citizen science is an important factor that should be taken into consideration when establishing sustainable DT models [26]. However, there is a lack of studies on sustainable DT at the micro level in the context of less developed countries. Thus, we aim to fill this gap in the literature. To understand the case, we used practice theory [27] as the theoretical lens. Practice refers to "embodied, materially mediated arrays of human activities centrally organized around shared practical understanding" [27, p. 11]. This theory allowed us to focus on stakeholders' activities, from individual to organizational levels [24].

## *2.2 Telecenters, Their Challenges, and Sustainability*

Telecenters (TCTs) have been established around the world due to their advantages of helping close the digital divide, improving equality, and developing societies and economies [28]. However, rapid technological changes are disrupting the traditionally successful business models of TCTs, as they no longer provide traditional telecommunications services (phone services, computer services, and the Internet). This has led to the disappearance of TCTs in the developed world, while the remaining TCTs in less developed countries face crises or are closed down due to unsustainable operations [29, 30].

To survive, TCTs need to evolve by transforming and shifting their traditional business models to new ones that can operate and adapt to technological and infrastructure changes [30–32]. A few examples of new models include e-health, e-learning, and e-commerce. Transforming TCTs using technology is considered one of the solutions to improving sustainability [32]. Unfortunately, while there are many studies on TCTs themselves, studies on this phenomenon in the new conceptual light of DT are scarce; thus, we focus on an analysis of such a particular case.

The sustainability of TCTs has been discussed in the literature. Although there are different factors in the models for sustainability, it is clear that the main common components of the models are economic or financial factors, social or cultural factors,

and environmental factors. Economic factors refer to the achievement of TCTs in terms of positive revenue. Social factors indicate the positive impact of TCTs on the socio-economic development of communities. Environmental factors indicate the environments in which TCTs operate. The literature also discusses that one of the most important environmental factors is the political and regulatory environment [33], while the technological factor is also important in the sustainability of a TCT, as technology allows a TCT to meet the needs of its users [34].

## 3 Research Methods

We used an interpretive, in-depth case study approach. We believe this approach is appropriate for our research, as an interpretive approach helps researchers understand the context and the process of IS [35] as well as allowing a view of the real world as socially constructed. We also adopted the principles of conducting a case study [36].

### *3.1 Case and Its Context*

The case study is of a state-owned company, VPN, which is based in Vietnam and has approximately 70,000 staff members operating in the fields of post, delivery, telecommunications services, distribution, and IT services (e.g., computers and Internet services). The company operates telecenters (TCTs) throughout the country. A telecenter refers to a physical location that provides services such as ICT, commerce, or e-government to communities, especially those living in isolated or remote areas. Telecenters were established in 1998, and as of 2018, there were approximately 8,100 TCTs across the country, providing services to about 90% of the rural population, or about 58 million people.

VNP's structure is divided into three levels. There are the VNP headquarters, 63 level 1 branches, and each level 1 branch has its sub-branches (level 2 branches). There are more than 8,100 TCTs across the country (level 3). In general, TCTs all over the country have similar settings, services, and business models. However, depending on the situation, TCTs can also have comparatively different operations. Telecenters are directly managed by level 2 branches, and indirectly by the VNP headquarters and its level 1 branches. Moreover, to understand the case study's context, we present the main statistics for subscribers of telephones, mobile phones, and the Internet in the country between 1998 and 2020 in Table 1.

**Table 1** Telephone, mobile phone, and internet subscribers per 100 inhabitants. *Source* Statistics Vietnam and MIC, 2021

| Year | Telephone subscribers | Mobile phone subscribers | Internet subscribers |
|---|---|---|---|
| 1998 | 2.6 | 0.001 | 0.00014 |
| 2009 | 20.2 | 113.4 | 26.5 |
| 2013 | 7.5 | 137.9 | 37.0 |
| 2016 | 6.0 | 139.2 | 54.2 |
| 2020 | 3.5 | 128.2 | 72.0 |

## *3.2 Data Collection*

Multiple sources of data were used in this study, including secondary data, surveys, and interviews. First, we gathered secondary data from various sources, including the authority in charge of TCT-related regulations, funding organizations or non-governmental organizations (NGOs) that sponsor TCTs (e.g., Bill & Melinda Gates Foundation, Public-utility Telecommunication Service Fund), VNP, and reputable magazines or news sources. The secondary data helped us primarily understand the phenomenon and complemented the primary data (e.g., interviews and surveys).

Second, we conducted a survey focusing on TCTs' staff and their customers in May and June 2020. The aims of the survey were primarily to understand TCTs' equipment, services, customers' and staff's background, the changes in TCTs over time, experiences of the staff at the TCTs, views on TCTs' overtime, their views on technologies, and to evaluate how TCTs adopt technologies.

Third, the input from the first two steps helped us establish topics and questions for the interviews. Semi-structured qualitative interviews with open-ended questions were used. We conducted 21 interviews from June 2020 to March 2021 (face-to-face) and two interviews from October and November 2021 (online). The list of interviewees and their positions are shown in Table 2. The questions were based on two main themes: sustainability and DT. Instead of recording, we took extensive notes during the interviews, which lasted from 21–75 min, and there were several informal conversations. During the interview process, secondary data (e.g., archival data) and information from the survey were gathered continuously. By doing so, it helped to triangulate information from the interviews.

## *3.3 Data Analysis*

We followed the guidelines of [37], and the process of data analysis was emergent and nonlinear [35]. During the data analysis process, we constantly moved between and reflected on the data and the theoretical lens and our research approach. We also used narrative analysis to inform the coding of our data [38]. We analyzed and traced the events and phenomena from both the internal and external contexts of TCTs [39].

**Table 2** List of interviewees, numbers, and their positions

| Interviewees | # | Position |
|---|---|---|
| Head of division | 1 | TCT Division, VNP Headquarters |
| CEO | 1 | Yen Bai branch of VNP (level 1) |
| Senior staff | 3 | Sales Division, Dak Lak branch (level 1); Sales Division, Kon Tum branch (level 1); and Krong Bang branch of Dak Lak's VNP branch (level 2) |
| Staff | 12 | Two staff in TCTs of Dak Lak branch of VNP, and 10 staff in TCTs of Kon Tum branch |
| Customer | 2 | Using services at the TCT of Dak Lak's Ea Tan branch of VNP |
| Head | 1 | ICT department of Hatinh province |
| Leader | 3 | Ha Mon (Kon Tum branch), Ea Tan (Dak Lak branch), Cu Sa (Dak Lak branch) commune committees |
| Total | 23 | |

In the early phase of the data analysis, we relied on secondary data. However, in the later phases, we used all data sources, time-mapping events, and constantly refined and analyzed the data based on all the sources. This helped us identify and categorize the phases and activities or phenomena in these phases. Three main phases of the sustainable DT of TCTs were identified at the end of the data analysis process. In addition to the narrative analysis, the authors discussed and refined this process, and all differences were bilateral agreements.

# 4 Findings

## *4.1 Sustainable Digital Transformation Process in the Case Study*

**Phase 1. Preparation phase**. After the period of inception and development, TCTs were forced to change their traditional business model due to digital technologies. The DT process was kickstarted by the company seeking out new digital initiatives. In this period (2009–2012, Phase 1, Table 3), TCTs across the country were significantly disrupted by technological changes that influenced their traditional business models. For example, the rapid growth of telephone, mobile phone, and Internet subscribers (Table 1) led to a massive loss of customers. Due to these external triggers, revenue streams at the TCTs gradually decreased. In addition, IT capabilities were also a problem. For example, the TCTs' equipment and technologies (e.g., software and hardware) were outdated. Further, the competition from other companies in the postal services led to the situation worsening. This led to the income being unable to cover operational costs. As a result, about 320 TCTs were closed temporarily, and the

operation of the rest was unstable or inefficient, as voiced by the head of the ICT department of Hatinh (level 1): "There were increasing trends in TCTs that they did not meet the operational [cost] conditions, while the rest of TCTs were ineffective, or in the stage of revenue losses or on the verge of bankruptcy."

Thus, TCTs had to change themselves in order to survive; VNP searched for new initiatives in order to deal with the significant changes in technology and infrastructure. Solutions to TCTs' challenges were discussed with the VNP management board. However, they had to find solutions, and even the discontinuation of services by closing down TCTs over the country was on schedule, as voiced by the head of the ICT department: "The management board was very slow in finding solutions. One

**Table 3** Timeline, context, and features of TCTs in the sustainable DT process

| Phase | Name | Period | Context | Features |
|---|---|---|---|---|
| 1 | Preparation phase | 2009–2012 | There was a rapid growth in telephone, mobile phone and Internet subscribers in the country (Table 1);<br>TCTs receive some support from external parties (e.g., funds);<br>Increasing number of competitors | Unstable development;<br>TCTs were in crisis, as traditional models did not generate revenues;<br>TCTs were forced to seek new business models, i.e., seeking digital initiatives to deal with the crisis and to sustain their businesses;<br>These digital initiatives were based on digital technologies |
| 2 | Trial | 2013–2015 | Mobile phone and Internet subscribers were continuing to grow at a fast pace in the country (Table 1);<br>Significantly growing competitors (about 200 competitors) | Several digital initiatives were proposed to transform their business models;<br>Trail business models at subsystem levels;<br>TCTs implemented digital initiatives and partly transformed their businesses |
| 3 | Implementation | 2016–2020 | Internet subscribers were very high (about 70%)—this percentage was close to the percentage of Internet subscribers in developed countries (more than 80%);<br>Continued growth in competitors (515 competitors in 2020) | Best practices of digital initiatives (business models) chosen from the trial phase were implemented at a large scale at all levels;<br>TCTs refined and continued to seek new digital initiatives;<br>More than 80% of the revenue came from new business models |

of the reasons is that there was a fast-changing technology infrastructure, leading to a significant loss of customers. Regulatory change was also a factor because it allowed more companies to provide services." The breakthrough ideas came to the new management board in early 2012, and VNP focused on seeking new business models that developed TCTs based on digital technologies—digital initiatives. Unlike the previous approach of seeking ideas from the management board, this time the ideas came from a variety of levels. They came from the sub-system level (e.g., from TCTs' staff), the organizational level (e.g., the board and TCT division staff at VNP Headquarters), and from society (e.g., customers and start-ups).

They also focused on the scope of the work, approaches, and products. It is interesting to note that the IT department was not in charge of DT work. Instead, a task force was established with people from different departments. As there was no universal understanding of DT in the company, it created many problems in practice. For example, it was difficult to decide for what scope DT should be implemented (organization-wide or limited), which approach should be used (short-term benefits vs. long-term benefits; sustainability vs. economic benefits; or top-down vs. bottom-up metrics for evaluation), and what would be the products and services that the TCT would offer (new cost-revenue business models or improved cost savings of the current models). This resulted in a set of documents for different solutions. As a result, several digital initiatives were chosen for the next phase, such as web-enabled e-government services, platform-based e-learning, platform-based e-commerce, e-health, and social insurance.

In terms of sustainability, the management board evaluated the digital initiative as follows: The economy was a strong factor, although there was a crisis at the end of Phase 1. Social factors focused on supporting reading services to all localities—that is, promoting culture, promoting public health, and reading culture reaching out to youth. There was no indication of environmental factors during this period. However, they provided information on environmental awareness to rural dwellers.

A summary of the process, its context, and its features can be seen in Table 3. The details of the next two phases (Phase 2 and Phase 3) are described in the following sections.

**Phase 2. Trial phase**. After the first phase, digital initiatives were selected. In this phase, the chosen initiatives were implemented to a limited degree in the TCTs—at the subsystem level. For example, VNP cooperated with its partners to pilot a project on social insurance via the TCTs, or PayPost app for financial services, and the PTCom app for ecommerce was installed at selected TCTs. It is noted that new digital initiatives came from several sources, such as society (e.g., start-ups and contests) and inside organizations (e.g., staff).

From those pilot initiatives, when they proved their advantages, new digital initiatives were considered best practices and became candidates to pilot on a larger scale at other TCTs at the organizational level; otherwise, they were halted. In other words, they used a "trial and error" approach to find best practices. The criteria for initiatives to be considered as best practices were financial, technological, social, political, and environmental factors, as voiced by the head of the division: "Revenue was our

first priority, as it contributed to the sustainability of TCT. Technologies played a central role in all of our selection steps as we transformed our business based on technologies. We also considered social factors, because the majority of our TCTs are located in disadvantaged areas, and political factors were taken into consideration because they affect TCTs. Finally, we took the environment as one of our criteria for a better life for the community." In this phase, new ideas were continuously refined and revised based on their performance according to these criteria. A priority was to increase revenue and move business models from basic services to multiple digital technologically-based services. It is noted that telecommunications services almost disappeared in TCTs; only postal services were in operation. However, it faced stff competition from other companies. For example, in 2016, there were more than 200 companies, in 2018, 250 companies, and in 2020, about 515 companies in the country provided similar services.

As seen, while economic factors continued to be considered as very important, social and environmental factors received considerable attention. This was thanks to a policy from the government that supported citizens in rural areas through TCTs (e.g., policies by the authority). Moreover, data from interviews showed that technology played an important role in sustainability, as almost all interviewees agreed on the importance of technology.

**Phase 3. Implementation phase**. In the implementation phase, VNP selected "best practices" to be expanded throughout the entire organization on an organizational level. First, they scaled up the infrastructure at both the back end and front end. Apps and platforms were officially introduced. Services were transferred to platforms and apps. Customers were also able to obtain their services online and offline via TCTs. At the organizational level, VNP was responsible for designing, setting up, updating databases, and processing business transactions. Alternatively, the TCTs assisted with the normalization of their customers' processes and guided them to use services that had improved efficiency during the trial period. For example, they used Postmart platforms (ecommerce) to help local farmers sell their goods. Through Postmart, TCTs cooperated with different service providers and service content to provide services to customers. Based on digital technologies, they were able to change business models to B2B, B2C, and C2C models.

As a result, revenue coming from services based on digital technologies accounted for more than two-thirds of the total revenue of TCTs. Other sources of revenue included postal services and financial services. For example, the survey indicated that, by 2019, more than 80% of revenue came from new business models, and only 16% of revenue came from traditional services. This helped VNP to contribute to communities. For example, TCTs were an important channel for assisting locals during the Covid-19 pandemic (e.g., services from governments, other benefits, or support from outside or other organizations). Telecenters continued to contribute and promote culture to locals (e.g., free books, policies, and magazines, with more than 1,730 TCTs of 57 level 1 branches participating, with more than 10 million users in 2018). Further, most of the 8,100 VNP TCTs' staff were members of the local communities and were in their 30s (e.g., 92% of the staff at Kon Tum and Dak Lak's

TCTs were local, more than 90% of the staff at Kon Tum and Dak Lak's TCTs were local women).

When it came to sustainability, as the economic factors were very positive, the company had more resources to focus on social factors. For example, the company prioritized hiring locals and continued to support and promote culture, public health, and awareness of environmental issues. In addition, the company received support from the government through the "One Commune One Product-OCOP" program (Decision No 490/QD-TTg issued by the Prime Minister, 2018). This was aided by technology. For example, apps and platforms were encouraged to be used and installed by all customers of TCTs. All services provided by TCTs were also available on apps.

## 5 Discussion

### *5.1 Sustainable Digital Transformation Process Model for a Firm*

Figure 1 illustrates a sustainable DT process model for a firm and its components, showing all phases of the sustainable digital transformation process. Each component of the model was generalized from our empirical data, which are described in the Findings section.

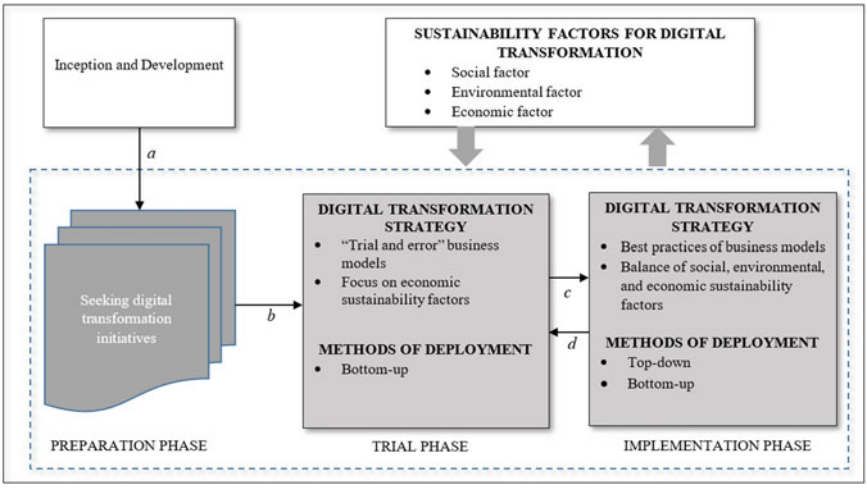


**Fig. 1** The process of sustainable digital transformation. *Note* The thin arrows represent transitions among phases, and the thick arrows represent influences among components. They do not represent a statistical or causality relationship

There are three phases in the process of sustainable DT: the preparation, trial, and implementation phases. During the preparation phase, a firm prepares to transform its business models using digital technologies. The trial phase shows the DT strategy and methods of deployment of digital initiatives in a firm, while the implementation phase illustrates how a firm transforms its business models on a large scale. Moreover, the methods of deployment indicate the scope and direction of DT, while the DT strategy indicates the strategy that organizations adopt in their transformation process. These strategies are influenced by sustainability factors (thick up-down gray arrows, Fig. 1). In turn, sustainability factors influence the DT process, as they play a role as both outside and inside influencers. However, these sustainability factors have different degrees of influence. The details of the model are described as follows.

First, in the preparation phase, after the period of inception and development, a firm has to seek DT initiatives for its survival for various reasons (arrow a, Fig. 1). These reasons are either intentions from inside a firm and planned [16, 36] or are mainly due to outside factors, as in this case. An example of an outside factor is technological change, which can take place outside the boundaries of a firm. This change leads to changes in customer behavior and affects how customers use services. For example, the number of subscribers on the Internet and mobile phones was growing at a rapid pace during a certain period, which led to a significant decrease in customers using phones or the Internet at service points. Instead, they could use it on their phones or at home. This was the main factor that led the firm into crisis, as traditional business models no longer produced enough revenue. To survive, a firm needs to change. In addition, after seeking DT initiatives, the firm chose potential initiatives to deploy in the trial phase (arrow b, Fig. 1). Digital transformation initiatives may come from both inside and outside of a firm, as evidenced by this case, in which they came from several TCTs, start-up companies, non-profit organizations, and even from the government.

Second, in the trial phase, "trial and error" is applied to digital initiatives. This means that each initiative will be implemented on a small scale within the firm. For example, a firm can choose to deploy certain services in different branches or areas across the country to implement DT initiatives. If these initiatives prove to be beneficial or have potential competitive advantages for the firm, they become "best practices." Next, the trial phase will move to the implementation phase (arrow c, Fig. 1). In the trial phase, a firm is mainly focused on the economic sustainability factor. The deployment methods are bottom up. This allows a firm to easily adjust and revise its business model in a manageable manner. Moreover, this phase also helps firms gain knowledge in DT, learn, train their human resources, and prepare their capabilities and resources for the next phase of the DT process.

Third, in the implementation phase, a firm adopts best practices from the previous phase and invests heavily in implementing these best-practice business models on a large scale. For example, a firm can now implement its initiatives in all branches and services. The chosen models are implemented in a top-down manner in the sense that they are implemented on a larger scale in all organizations at different levels, from headquarters to branches. At the same time, a firm continues to use its "test and trial" approach to revise its current business models or deploy new ideas in a

limited number of branches or services (arrow d, Fig. 1). By doing so, it helps a firm continue its renewal and take advantage of digital technologies. It also helps them achieve dynamic and flexible change with high competitiveness and growth. Moreover, a firm can achieve a better balance in terms of sustainability factors, such as economic, environmental, and social factors.

### *5.2 Relationships Between Sustainable Factors in Digital Transformation*

Due to the enormous pressures of rapidly changing digital technologies and the uncertainties of environments [22], many firms around the world are facing uncertainty and unsustainable operations. Thus, it is important for companies to seek sustainable business models to ensure their survival. Economic sustainability is a key factor in DT, which is very challenging for firms seeking a balance with other factors, such as environmental and social factors. This is because economic sustainability is a major concern in any ICT project and is the main reason why many firms close down [40–43]. Moreover, this study indicates that economic factors are a major motivation that leads TCTs to transform their services.

During the DT process, a firm needs to take into consideration social and environmental factors to achieve sustainability. As shown in the case study, TCTs provided various services and activities in the country to close digital gaps, promote culture, and help others, especially for those citizens in rural areas. For example, TCTs were used for social insurance, social assistance, and other services, which helped to increase the company's reputation and acceptance by the community.

In our study, in addition to economic, social, and environmental factors, digital technology and political factors indirectly influenced the sustainability of DT. For example, as demonstrated in the case study, government policies helped TCTs facilitate and expand their services to a wider range of customers. Through these policies, TCTs were able to provide e-government services to citizens and establish their services in communities. Such government support can contribute to economic and social factors in the process of sustainable DT [42, 43].

## 6 Conclusion

We contribute to the literature by introducing a process model for sustainable DT in firms. We showed that the process of transformation can be unintentional and influenced by external factors. These external factors led a firm to change its business models for its survival in different ways at different stages. The firm needed to balance three factors: social, economic, and environmental factors. Furthermore, we also found that technological and political factors can aid a firm in achieving

sustainability. These findings can be seen as the practical implications of this study, as managers should consider sustainability factors when implementing sustainable DT.

This study has several limitations. We used a specific case in a specific country in this paper; therefore, our conclusions may not be applicable to other organizations or in other countries, especially those with different contexts. However, we believe that our findings may be useful for similar organizations. In the future, we plan to conduct and analyze each phase in depth and explore how different sustainability factors affect each other during the process of transformation. We also aim to further examine the model that we proposed in the present paper to gain a better understanding of how the process of transformation unfolds over the years or to analyze in depth the relationship between capabilities and resources for DT in our case.

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